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REFLECTORS,

BEING A DESCRIPTION OF THE

NEW ASTRONOMICAL TELESCOPES

WITH

SILVERED-GLASS SPECULA;

AND

INSTRUCTIONS FOR ADJUSTING AND USING THEM.

BY

JOHN BROWNING,
F.R.A.S., F.M.S., & F.M.S.L.

SIR WILLIAM HERSCHEL,
From an original Seal in the possession of the late R. W. S. LUTWIDGE, Esq., F.R.A.S.

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INTRODUCTION.

Those who have only seen the heavens with the naked eye would do well to examine various portions of the sky, on a fine clear night, with an ordinary opera glass. Some thousands of stars will thus become visible in the milky way; many stars that before appeared single will be found double. The Pleiades, Hyades, and many other interesting clusters will be seen with increased beauty, and the nebulæ in Andromeda and Orion may be perceived whenever these constellations are in a favourable position for observation—that is, at a sufficient elevation above the horizon.

The lunar crescent, holding in its silvery embrace the faintly illuminated globe, affords a charming spectacle a few days after new moon, and about the first quarter the mountains and craters on the shaded edge will also be discerned, although not well made out. As all this can be done with an instrument, magnifying only at the most three diameters, the observer may imagine what can be seen with an instrument that will magnify 300 diameters (90,000 times superficial), and such a power the smallest telescope described in this list is supplied with, and will perfectly bear.

The greatest number of stars visible to the unaided eye on a clear night is estimated at less than 3,000, while the number visible by the aid of a powerful telescope has probably been under-estimated at 10,000,000.

In one part of the heavens in the constellation of Gemini, where seven stars are visible to the naked eye, the same space is represented, on a telescopic star map constructed by M. Chacornac, as containing 3,205 stars, and these were seen with a telescope of only six inches aperture.

Sir William Herschel estimated the number of stars in the bright zone, known as the milky way, at eighteen millions, and Chacornac considers this estimate far too small.

It is well known that nearly the whole of Sir William

Herschel's numerous and important discoveries were made with reflecting telescopes.

More recently, great additions have been made to our knowledge of the celestial bodies by Lord Rosse, Lassell, Nasmyth, and De la Rue, all working with reflectors. Why, then, have reflectors fallen out of general favour, and why are they now regaining their true place in public estimation?

To see well the markings on the planets, or to observe nebulæ, perhaps the most interesting, certainly the most inexplicable of all the celestial objects, telescopes of large aperture are indispensable; an aperture of six inches being almost the smallest that can be employed successfully in viewing them. Yet the great cost of a good achromatic object glass, of even six inches diameter, places it beyond the reach of all but wealthy persons.

For exploring the wonders of the heavens, the greater cheapness and portability of reflecting telescopes of large aperture would probably have led to their more general adoption, instead of the achromatic or refracting telescopes usually employed, but from many specula having been made of imperfect parabolic figure—from their having been fitted up without proper precautious to prevent injurious flexure—from their having been generally placed in wooden tubes, and frequently mounted on unsteady stands, and finally, from incorrect planes having been used as diagonal mirrors, their performance was unsatisfactory. The introduction of silvered glass mirrors, and of the methods of mounting subsequently described in these pages, have entirely removed these objections.

Astronomical telescopes, constructed with silvered glass specula, possess the following important advantages:—

They are only half the length of achromatics of the same aperture.

Their dividing power, on many stars, is superior to that of achromatics, aperture for aperture, as they give smaller discs; and on the moon and planets their performance cannot be surpassed.*

* See testimonials at the end of this pamphlet.

They are quite free from the aberration of colour.

When viewing objects in the best position for observation—that is, between the zenith and 45° above the horizon, they are much more convenient to use than refractors, because the eye-piece of the reflector remains nearly horizontal; a refractor, under the same circumstances necessitates the observer almost lying down on his back. Micrometric measurements may be obtained with great exactitude, from the easy position of the observer.

The price of the specula in small sizes is only about one-fifth; and, in large sizes, only one-tenth, of that charged for good achromatic object-glasses of the same aperture.

For instruments of equal power the new reflecting telescopes do not require an observatory half the size that would be necessary for a refractor, and a building half the size would not be one quarter the expense.

These advantages, when known, must lead to the universal adoption of this instrument by that numerous class of astronomers who require powerful telescopes, but cannot afford the great outlay at which only refractors of large aperture are obtainable.* The Moon Committee of the British Association has recommended that those observers, who desire to assist them in their labours, should observe with a power of 1,000 diameters. An object-glass, which would bear this power with advantage, would cost from £200 to £300. A silvered glass speculum, which would bear this power, could be obtained for £36 6s. From this it is easy to see that, when silvered glass specula are more generally used, the number of observers able to employ high powers will be enormously increased.

* Although I am aware my motives may be misconstrued, I feel it only right to warn intending purchasers of telescopes against being misled by the numerous advertisements of cheap telescopes which are continually appearing in the public papers. The various objects they are warranted to show, are such as can be seen with any telescope having an object-glass of three inches aperture; no objects are mentioned which would be tests of performance in definition. I have had to replace the object-glasses of several of these so-called cheap telescopes with others. The magnifying powers of the eye-pieces supplied with such instruments are often absurdly exaggerated. In one brought to me for alteration, I found an eye-piece engraved 70 only magnified 13 diameters. Of this telescope the owner has recently written to me, "I am afraid I shall not be able to do much now with your new object-glass, for the stand is as shaky as a fishing-rod."

In a paper, by Mr. Wray, read before the Astronomical Society, on the correction of the secondary spectrum in achromatic object-glasses, the writer claims that one of his new and perfected object-glasses "gives stellar images exactly similar to those shown by a well-corrected reflector." This, from a clever practical optician, I regard as the most favourable testimonial yet written in praise of good reflectors.

Those who have been used to observing will best understand the relative powers of the specula, of various aperture, by a statement of their performance on certain selected double stars; but a better idea of their respective powers will be conveyed to those less accustomed to working with the telescope by a statement of their performance on the planets. For this purpose I select Jupiter and Saturn as the two best known planets of our system.

Jupiter affords the telescopic observer one of the grandest sights in the heavens, a magnifying power of only 40 diameters sufficing to give it an apparent diameter equal to our moon. Very interesting views of the belts of Jupiter may be obtained with a 6½-inch speculum, and powers of from 250 to 300. The continually changing positions of his four satellites, their eclipses, as they successively pass through the shadow of their primary, and their transits across his globe, accompanied by their shadows, are phenomena of great interest, the beauty of which is of course enhanced by increased aperture. The 8¼-inch speculum shows the deep coppery hue of the equatorial bands, and the varied but less intense tints of other portions of his disc, as well as those minute details of his belts, the continual changes of which have of late rendered this planet an object of peculiar interest.

Saturn requires more telescopic power than Jupiter, not only on account of his smaller diameter and increased distance, but owing to his complicated system of rings, and the number and minuteness of his satellites. The four brightest of his moons are readily visible in a 6½-inch speculum, and the principal division of the ring, as well as the inner dusky ring, and traces of the faint belts on the globe. The shadows of the rings on the globe and of the globe on the rings, are

sharply defined, and may be observed continually varying, owing to the continually changing relative position of the planet with regard to the sun and earth. In addition to the above details the 8½-inch speculum shows the delicate gradations of light on the rings, and under favourable atmospheric conditions the fine division of the outer ring. In a 12¼ speculum this planet presents a spectacle of singular beauty. The sharply defined globe with its numerous belts symmetrically placed within the gracefully encircling system of rings, the varied tints of which are strikingly visible with this large aperture, as well as his numerous and ever changing attendant moons, form a picture which when once seen is never forgotten.

The 8½-inch speculum will show six satellites, and, in addition to all the foregoing details, the gradations of light on the rings, and, under the most favourable circumstances, the division in the outer ring.

It is not pretended that the details just mentioned will be easily seen at any time by an untrained observer; but practised observers, under favourable circumstances, will certainly be able to do more than is here stated.

To bring out the full powers of these or any other telescopes the objects must be favourable situated, the air must be fine—that is, clear and steady; and, beyond this, the observer must have had some practice in seeing minute details with low powers.

It seems but little understood that the eye is capable of being trained no less than the hand.

The snow caps on Mars, as well as some of the seas which intersect his ruddy globe, can be seen with a 6½-inch silvered glass reflector, but the 8½-inch aperture is about the smallest size with which successful view of this planet can ordinarily be obtained, since owing to his small apparent diameter, which in the most favourable situations does not amount to half that of Jupiter, a comparatively high power is required to enable his markings to be distinctly made out.

During the favourable opposition of 1867, the writer obtained a series of interesting views of the details of Mars, these present appearances resembling in some respects those which we

might imagine our own globe to exhibit to a distant observer. No spectacle can well be more fascinating than the sight of this miniature of our globe suspended in space revolving slowly on its axis, and bringing continents and seas in slow succession under the gaze of an observer.

I have been frequently asked to state the power of reflecting telescopes, as compared with achromatic telescopes. From a comparison of the results of several observers I have concluded that, in light-grasping powers, they are equal to an achromatic, one-sixth less in diameter; while as regards their dividing power—that is, their power of separating double stars —they are fully equal to the finest achromatics of the same aperture.*

The 4½-inch, with powers from 100 to 150, will divide:—

α Lyræ. 32 Orionis.
δ Geminorum. ϵ Hydræ.
ξ Ursæ Majoris. o Draconis.
ϵ Bootis. 39 Draconis.
γ Ceti. ϵ Draconis.

And as test of light-grasping qualities, the companions of α Lyræ, α Tauri, and Rigel. The attendants of the first two stars are about 11th magnitude, and of the last 9th magnitude.

The 6½ will divide, with powers from 200 to 300:—

ϵ Arietis. α Herculis.
ζ Bootis. 32 Orionis.
ι Equulei. η Coronæ Borealis.
36 Andromedæ.

And clearly show the delicate pair between ϵ^4 and ϵ^5 Lyræ, also the companion of α Serpentis, rated by Smyth as of the 15th magnitude, and termed very delicate with the Bedford telescope, having an object glass of $5\frac{8}{10}$ clear aperture.

The 8½ with powers from 300 to 350, in a favourable state of the air, will divide:—

γ^2 Andromedæ.
μ^2 Bootis.

With a mirror this size and a power of 250, the close double following Procyon is clearly separated by a distinct

* Since writing the above, the Rev. T. W. Webb has kindly informed me that he has found a 6½-inch silvered glass mirror had the advantage on a light test over his 5½ achromatic, by Alvan Clark.

dark interval, and a somewhat higher power easily splits the difficult double near Castor, on any night of ordinary clearness.

These last named double stars* are so difficult to divide as to have, hitherto, been considered good work for a 12-inch speculum.

For the instructions for silvering glass specula, contained in Appendix I., I am indebted to the kindness of Mr. With.

DESCRIPTION OF THE SILVERED GLASS REFLECTING TELESCOPES.

These telescopes are of the kind called Newtonian, a form so well known, that it is, perhaps, scarcely necessary to describe it; but I append a plain diagram (Fig. 7) and brief description, because it will assist in making clearer the instructions I have given further on, of the method of adjusting the instrument. The Newtonian telescope consists of a tube closed at the lower end, which is occupied by a concave mirror M. The cone of rays reflected from this mirror is again reflected at right angles from the surface of a small plane mirror, *m n* mounted at an angle of 45° near the open end of the tube, into the eye-piece, which is exactly opposite. The path of the rays is shown in the diagram (Fig. 7)†, page 28.

In reflecting telescopes, as originally constructed, the concave mirror was made of an extremely hard alloy, known as speculum metal. These metallic mirrors possessed several

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* I have not been able to find that these stars have even been fairly divided by any achromatic of less than eight inches aperture, and that of admirable quality.

For an extensive list of stars, clusters, and nebulæ, the writer can recommend Mr. R. A. Proctor's "Half Hours with the Telescope," to beginners, and the Rev. T. W. Webb's charmingly written little book, "Celestial Objects for Common Telescopes," of which a second edition is now ready, to those who have exhausted Mr. Proctor's work.

Mr. Proctor's "Half Hours with the Stars" will be found a useful atlas for a beginner, and his "New Star Atlas" is by far the best observatory atlas with which I am acquainted.

† The mirror must not be worked to a spherical, but to a very perfect parabolic curve. Those desiring information on this rather obstruse subject may read Appendix II.

disadvantages so serious in character, that they have, for some time, fallen out of general use. The principal defects were the following:—

1. From the extreme brittleness of the alloy they were very liable to fractures, sometimes breaking merely from a sudden change of temperature.

2. From their great weight it was extremely difficult to mount them in such a way as to prevent flexure, the smallest amount of which greatly injured their optical performance.

3. Their greatest drawback, however, consisted in the fact that the surface of the metal, from damp or other causes, sometimes became very rapidly tarnished, and this tarnish could seldom be removed, except by repolishing, and, consequently, refiguring the mirror; and this involved nearly as great an outlay as the purchase of a new speculum, besides incurring the serious risk of a fine figure being irretrievably lost.

In the telescope now described, the metallic mirror is replaced by one of glass, on the surface of which a coating of pure silver has been deposited by Liebig's process.

These glass mirrors are not at all injuriously affected by change of temperature, and their lightness very considerably reduces their liability to flexure; indeed, mounted in the manner I shall presently describe, no flexure has ever been observed in them. I may, however, state that I make the discs of the specula, which Mr. With parabolises for me, out of glass nearly twice the substance of that generally used for the purpose. The coating of pure silver reflects fully one-third more light than the best speculum metal, as the alloy before mentioned is called. But the greatest superiority of silvered glass over metallic mirrors consists in the fact that, should they become tarnished, their brilliancy may readily be restored by gentle friction with soft leather, and a little of the finest rouge; and even should the silver coating become utterly spoiled, it may be easily removed, without in any way impairing either the figure or polish of the glass speculum, and a fresh one deposited at a trifling cost, thus making the mirror equal to new; and this may be repeated indefinitely. Should

the owner possess a little patience, he may renew the coating himself at the cost of only a few pence. The silvering process is fully described in an appendix.

With this alteration, these telescopes have, latterly, rapidly gained ground in the opinion of practical observers, well known in the scientific world, who have had considerable experience in working with them. Letters received from some of these observers will be found at the end of this pamphlet.

On Figuring Specula.

About eleven years since, the Rev. Cooper Key discovered a more simple method of parabolising the surface of specula than any which had hitherto been employed, and by this process he produced two fine specula of twelve inches diameter.

The process by which these specula were worked, Mr. Key communicated to Mr. G. With, and after having worked by Mr. Key's process for about four years, Mr. With discovered another plan of working by which he considers still finer results are with greater certainty secured.

The wonderful perfection of Mr. With's specula is now generally admitted, and it is almost certain that they surpass any that have previously been produced. I have great pleasure in stating that specula of Mr. With's parabolising are now only to be obtained from me.

On Mounting Specula.

It has elsewhere been suggested that much of the dissatisfaction which has been expressed by those who have used reflectors, has arisen from their having been imperfectly mounted.

Because specula are much cheaper than achromatic object glasses, it has been supposed that they could be mounted at proportionately less cost than that incurred in mounting refractors. This is only true to the extent that cost can be saved by reason of their shorter focal length.

It cannot be too strongly enforced, that, to give the best performance, reflectors require to be mounted more steadily than refractors, because, by a well known law in optics, the

effect of any vibration will be multiplied many times. Thei tubes must also be carefully arranged, so as to avoid, as mucl as possible, the interference of air currents, which are th bane of reflectors improperly mounted, or badly situated. Th specula in the telescopes now described are mounted rigidly on a new plan, which insures permanence in adjustment, an prevents flexure. This plan is represented in Fig. 1.

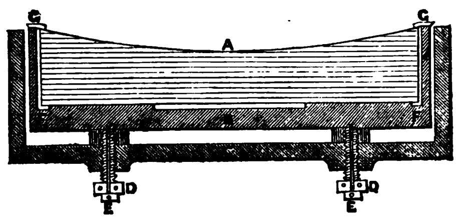

Fig. 1.

The bottom of the speculum A is a carefully prepared plan surface, and the bottom of the inner iron cell B, on which i rests, is also a plane. The speculum is kept in this cell b the ring G G, and it may be removed from, and replaced in the telescope, without altering its adjustment. The elasti methods of mounting the speculum, which have hitherto bee employed, generally required re-adjustment whenever th speculum had been removed. The reflecting diagonal prism or mirror, is mounted in the manner shown in the diagrams and 3.

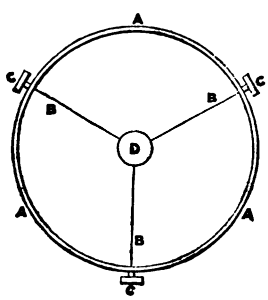

Fig. 2.

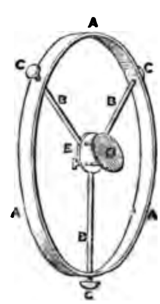

Fig. 3.

In these B B B represent strips of strong chronomete spring steel, placed edgewise towards the speculum, by whicl the prism or small mirror D is suspended.

The mirror thus mounted does not produce such coarse rays on bright stars, as when it is fixed to a single stout arm; it is also less liable to vibration, which is very injurious to distinct vision, or to flexure, which interferes with the accuracy of the adjustments.

If an observer determines to lay out a given sum in the purchase of a telescope, he will find it to his advantage to have a smaller speculum completely mounted, instead of a large speculum imperfectly mounted. With the smaller and perfect instrument he will really do more work, and with much greater comfort and satisfaction to himself. No matter how good a speculum may be, nothing can be told of its performance on difficult double stars if it is mounted on an unsteady stand.

THE SMALL ALT-AZIMUTH.

The Alt-azimuth stand, represented in Fig. 4, page 18, is entirely of iron. The tube of the telescope is of extremely stout

Fig. 4.

block tin, coloured dark green, the stand being coloured dark chocolate. The body is equipoised, so that it will remain in any position, while the movements are so smooth, and the leverage so arranged, that a star may be followed, even with a power of 300, without screw motions. The instrument can be used on a table, at any window, and a stand is supplied with it, on which it can be supported at a convenient height, when it is used in

the open air. This mounting is only adapted for a small sized speculum, say not exceeding 5 inches in diameter, as, if made of a larger size, it would be so heavy as not to be portable; while with higher powers than 300, such as specula of 6 inches, and above, will easily bear, the celestial bodies cannot be followed without screw motions. By fastening the circular foot down on a block of wood of a wedge form, the angle being the complementary angle to the latitude of the place, this stand can very readily, and at a comparatively trifling expense, be made to move equatorially, so that the heavenly bodies can be followed with a single motion of the telescope. Such an arrangement is shewn in Fig. 4, page 15.*

THE EDUCATIONAL REFLECTOR.

This instrument was designed at the request of the Rev. Charles Pritchard, the Savillian Professor of Astronomy at Oxford, for educational purposes. It will be found the most economical instrument that can be purchased, which will give an observer a great command over an infinite variety of astronomical objects. In dividing double stars this instrument will compare favourably with Achromatics of equal aperture. It has a $4\frac{1}{2}$-inch speculum of 5 feet focus, and is mounted on a stand which can be changed from alt-azimuth to parallactic, so that the stars can be followed with one motion. This motion can at pleasure be communicated by means of an endless driving screw and Hook's joint. (See Fig. 5.)

THE LARGE ALT-AZIMUTH.

The large Alt-azimuth stand, of which Fig. 6 is a sketch, is well adapted for specula of 6 inches diameter, and upwards. It has quick and fine screw motions, both in altitude and azimuth, by means of which the motions of the heavenly bodies may be followed with facility. A reference to Fig. 6 will soon make it clear how these motions are obtained. On unclamping the small screw which projects on the left hand side, on a level with the top of the stand, the telescope can be raised or lowered to any extent, and on re-clamping the small screw it will be retained in the desired position. The fine

Fig. 4.

Fig. 5.

motion in the same direction is given by simply turning round the large milled head, which is shown on the under side of the telescope, near the top. To move the telescope horizontally, a clamp screw must be released, which is attached to the tangent screw, shown on the right hand side of the stand, just above the arc of the instrument, when the telescope can be moved to any part of the arc. The fine motion, in this direction, is obtained by turning the tangent screw. This is done by means of a square key, which fits on the end of the tangent screw, the key having a long handle, and being furnished with a Hook's joint, which enables it to be turned freely when nearly at right angles to the tangent screw. The telescope is equipoised on trunnions, and it can be instantly taken off the stand at pleasure.

The whole of the stand, telescope, and mountings are of metal, excepting the legs, which are very strongly made of wood, well braced together. It is exceedingly steady, indeed, as steady as any stand can be made, without adding enormously to its weight.

A large number of these Alt-azimuth instruments are now in use. They are contrived specially so as not to be too heavy to be moved about. When I know they are to be taken in and out at night, I put a wheel on the front leg of the stand, and adapt a pair of moveable handles to the two back legs, or those nearest the observer, and the instrument can be lifted by these, and wheeled to any required position. The handles instantly come out of the sockets, and, there being only one wheel and two firm legs, the instrument is not rendered unsteady.

THE EQUATORIAL.

The stand shown in Fig. 7 is known as an equatorial mounting. In a stand made on this plan, when the centre of the inclined hour circle, round which the telescope turns, is directed towards the pole of the heavens, to which it will exactly point, and when a star is brought into the field of view, it may afterwards be kept in view by communicating a motion in one direction to the telescope.

Again, on finding the position of any star or planet, in an almanac, and setting the two verniers on the instrument to the position given, allowing for the difference of time from the object being on the meridian, the desired object will, if the stand has been correctly adjusted, be found in the field of view. In this manner stars may be found, and well seen in the day-light, even when the sun is shining very brightly.

With Mr. Slack's 6½-inch mirror I have seen ε Bootis well divided, and the colours finely displayed in sunlight. On one favourable occasion the writer saw γ^2Andromedæ divided with this mirror.

Those who have equatorial stands will often find *about an hour before sunset* a good time for observing difficult stars.

In this equatorial stand I have endeavoured to combine compactness and steadiness, and withal, the utmost economy with which perfect efficiency could be secured; complete steadiness being the principal object aimed at in its construction.

This has been secured by making the hour circle of larger diameter than usual, and giving it a carefully ground bearing round its extreme edge; and by making the declination axis, to which the telescope is attached, much stouter than it is generally made, in proportion to the size of the telescope. The divided circles are of brass, the rest of the stand is of iron.

The body, containing the eye-piece and prism, revolves, so that the eye-piece and finder can always be placed in a convenient direction for observing.

While the revolving body and eye-piece give great facilities for using the telescope in various positions, it is extremely difficult to adjust the body so accurately, that in turning it round the image shall not have a slight motion in the field of view of the eye-piece. Such a motion will alter the reading on the circles.

This difficulty may, however, be obviated, by reading the circles with the eye-piece always in one position and by noticing any error in the places of stars, observed when it is in that position, which will be a constant quantity so long as the adjustments are not changed.

The new model Equatorial, with clock work, Fig. 8, was designed and made for Lord Lindsay, F.R.S.; the clock is placed

Fig. 6.

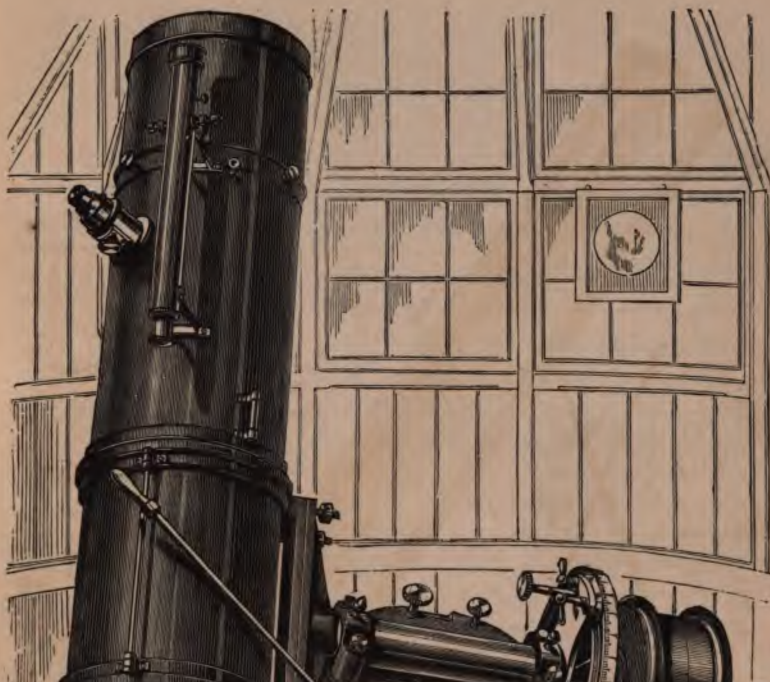

Fig. 7.

on the north side of the instrument, so as to be quite out of the way of the observer when using the Telescope, and is thus protected from injury by means of cords, a star can be made central in the field of view, from the eye-piece of the Telescope, if required, at a slight additional expense. The body of the Telescope can also be made so that the observer can cause it to revolve without leaving the eye-piece.

The Astronomer Royal's moveable hour circle has been adapted to this instrument, by means of this contrivance stars can be set off on the circles from any catalogue without calculation, thus saving time and preventing mistakes. The instrument can be made to follow a star in declination as well as right ascension from the eye-piece, by means of an endless screw and worm wheel.

The frontispiece to this pamphlet is copied from a coloured drawing made by the writer; it represents Jupiter as seen with a 12½-inch reflector.

TO ADJUST A REFLECTING TELESCOPE AS MADE BY JOHN BROWNING.

If the speculum has been removed from its cell, carefully dust the under part, and free it from grit, as well as the bottom of the cell, before replacing it, then screw on the ring which confines it in the cell. Before screwing on the ring, should the speculum be loose in the cell sideways, insert a few long slips of stout white paper between the edge of the mirror and the cell, *but leaving the slightest possible shake.* Having placed the mirror and cell in the telescope, and secured it by means of the three milled head screws, *with the cover on the mirror,* remove the glasses from one of the eye-pieces, D Fig. 7, page 28, and screw it into the eye-tube.

To Adjust the Diagonal Mirror or Prism.

Now, looking through the eye-tube, move the diagonal mirror, *m n* Fig. 7, page 28, by means of the two motions which are

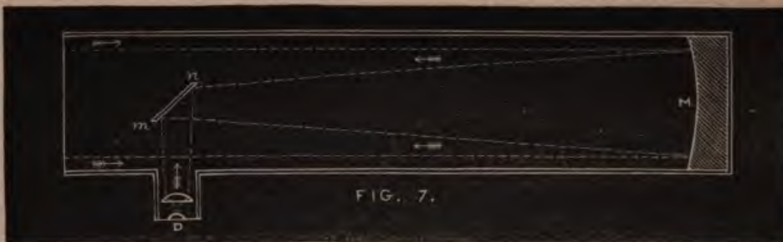

FIG. 7.

provided, until the reflected image of the cover of the speculum is seen in the *centre* of the small diagonal mirror, or prism.

To do this, loosen the milled-headed screw behind the mounting of the diagonal mirror, turn the mirror until the image of the speculum cover appears central in one direction, and reclamp it by means of the screw.

The screw, close to the back of the plate on which the mirror turns, will enable the reflected image to be brought central in the other direction, and on clamping this screw the adjustment will be correct.

To Adjust the Speculum.

Next take the cover off the speculum, and replace the speculum in the telescope. Then move the screws at the bottom of the outside cell, which contains the mirror, until on looking into the eye-tube, the image of the small diagonal reflector is seen in the centre of the reflection of the speculum. The large hollow screws serve to move the mirror; the small screws, which run through their centres, clamp it in position without straining it. Having clamped these screws, the adjustment will be completed, and the telescope may be turned upon an object, and focussed in the same manner as an ordinary refractor.

To Perfect the Adjustment of the Plane or Prism.

Having carefully followed the directions for adjusting just given, turn the telescope upon a bright star, or if in day time upon an artificial star; put on a high power, *i.e.*, about 40 to the inch of aperture or more, and observe whether the focal

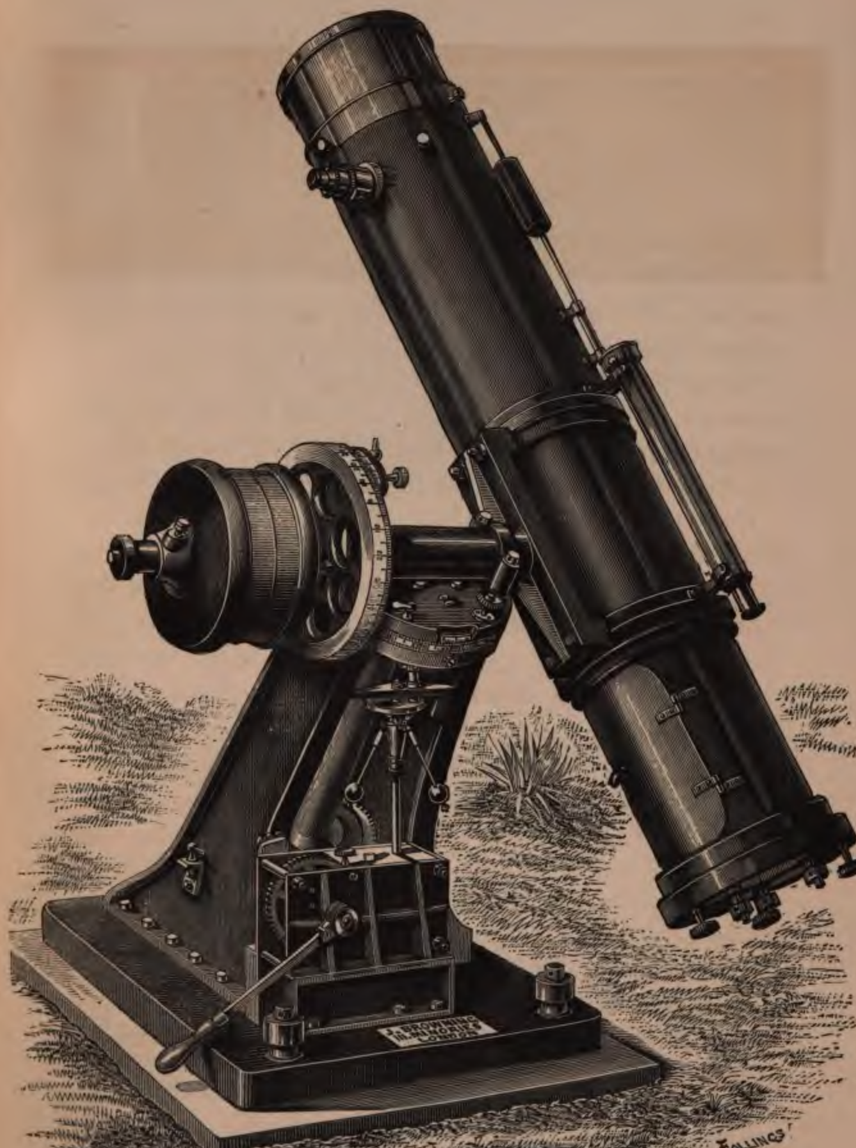

Fig. 8.

image is deformed by a flare in one direction. If not, the adjustment of the plane is perfect.

If a flare appears on either side of the image, that part of the plane towards which the flare projects is to be moved from the observer.

To Adjust the Finder.

To adjust the finder, get any strongly marked terrestrial object, at a great distance, into the centre of the field of view of the *large* telescope, with a tolerably high power. Then, looking through the small telescope, move it by means of the screws in the rings, until the object is exactly bisected by the cross wires in the field of view.

Now perfect the adjustment by carrying out a similar operation, using a bright star instead of a terrestrial object.

TO USE A REFLECTING TELESCOPE.

The principal difficulty in using reflecting telescopes arises from currents of air being formed in the tube, which produce unsteady vision.

These tube currents are almost entirely avoided in the telescopes now under consideration, by making the tube of iron, which quickly equalizes the temperature within and without the tube. Reflecting telescopes perform best in the open air; but should an observatory be built for their reception, it should be constructed of sheet iron, as, when this material is used, the temperature within and without the building will be always nearly equal, and annoying air currents, which would be generated in a building made of non-conducting material, will be much reduced. The observing-room should be larger than will just allow of the telescope being moved about freely. When more than usually difficult work is attempted only one person should be in the observatory; by having a second person present the temperature of the interior of the building will be augmented; also the slightest movement on the part of a second person will produce perceptible vibrations when high powers are being used.

An equatorial reflector, with an aperture of 8½ inches, I have

made for the late Mr. R. W. S. Lutwidge, that gentleman has had placed upon the porch of his house. It is protected by a moveable cover, Fig. 7*, and is thus used in the open air. This telescope will bear a power of 500 in a state of weather when another of the same kind placed in an observatory, with a narrow slit in the dome, will scarcely bear a power of 200.

Fig. 7*.

The kind of observing-room best adapted for reflecting telescopes is that proposed and adopted by Mr. Slack. This contrivance consists of a glass room of an oblong square form, each side furnished with six sliding glazed frames reaching from the floor to the roof. One half of the roof slides back under the other. There are four sashes in front of this construction, two larger and two smaller, and by different arrangements of the whole set, every part of the field of view can be uncovered in succession, and the whole chamber is easily reduced to the same temperature as the external air.

Whatever plan be adopted, at least half the roof must be open when observing. The revolving dome, with a single slide or shutter in it, is quite inadmissible for use with reflectors.

Before observing, the instrument must be as much exposed to the air as possible for some time, to equalize its temperature with the surrounding air.

The temperature of the observatory when observing must never be allowed to exceed that of the outer air by more than

one degree; and even if it exceeds it by only half a degree high powers cannot be used with the best results.

Since the above was written, one of my friends has constructed an observatory, which in appearance resembles a very elegant summer-house, but is yet far more efficient than any other contrivance I have hitherto seen. The roof is octagonal, with a flat top to admit of a zenith view, and two sides of it opposite to each other, can be completely opened at the will of the observer. There are windows in the four sides, and ventilating boards under the eaves all round. I have seen a thermometer in this observatory, after the sun has been shining on it, only half a degree higher than a thermometer placed in the open air. A telescope used under such conditions would not work at any practical disadvantage.

The use of a diaphragm one quarter less than the full aperture will improve the performance of the instrument on some objects, such as stars of the first magnitude, and also on objects generally when the air is exceptionally unsteady.

The performance of a telescope should never be condemned from a single trial, or, indeed, after many trials. From unsteadiness of the air, the finest instruments that will at times divide stars less than half a second apart, will not, upon some nights, separate stars two or three seconds asunder.

The air is, generally, the most unsteady from inequality of temperature about an hour after sunset. This time is, therefore, ill adapted for observing particularly difficult objects. In London, the air improves greatly in steadiness as well as clearness, after midnight. After rain has fallen, the air is generally both clear and steady, and therefore well adapted for observing.

Very erroneous opinions are generally held as to the powers which may be applied to telescopes of large aperture with advantage. Were the air always steady, mirrors or object glasses of perfect quality would, of course, bear a magnifying power only limited by the light of the object. But owing to perturbations of our atmosphere, it will be found, that as the effect of these increases with the area of the object glass, or speculum, on the majority of nights, higher powers may be

employed with instruments of moderate aperture than with those of large aperture. As an instance of this, I may mention that, when working with an 8½ mirror, I generally used a power of 210, while latterly using a 12¼ mirror of equally fine figure I have nearly always had to observe with a power of 146. Yet with this I see much more than with the 8½, and power 210. The superiority arises from the increased defining and separating power due to large aperture. This, however, unless seen with a high magnifying power, is nearly always overlooked by an unpractised observer. On occasional nights, or during some portion of a night, the air will be steady enough to permit of high powers being used, such as 50 to the inch on planets, or 75 to the inch on the moon, or the stars; *then* the value of large aperture will be realized.

To those who do not object to the expense, a clock-work motion attached to an equatorial telescope is a great luxury. In the event of clouds obscuring the view, a clock will keep the telescope going, and when the clouds disperse, the star or other object is instantly visible to the observer. The writer has frequently left his large telescope to take tea or supper, and found on returning to the telescope the object he had been observing still in the field of view. For drawing, the clock-work motion is almost a necessity, and for measuring the diameter of the planets, the distances of double stars, or their angles of position, unless the observer possesses a double image micrometer, the clock-work motion becomes indispensable.

ON THE USE OF STOPS.

Diaphragms, or, as they are more commonly called, stops, should, as I have elsewhere stated, be used to diminish the working aperture of a mirror wherever the air is unsteady, and particularly when the star or double star under observation is of large magnitude.

With a mirror of 6½ inches diameter, stops are seldom necessary, and when applied will rarely prove of service in improving the appearance of the object; yet when the night is

clear, and the stars flash more than usual, a 5-inch stop may be used with advantage.

With an 8-inch mirror a 6-inch stop is often required when observing such stars as I have above indicated, and a 7-inch stop, will, on nights when the air is very unsteady, bring out more clearly the markings on the planets.

When larger mirrors than the $8\frac{1}{2}$-inch are employed, some skill, only to be acquired by practice, is required to suit the stop to the object under examination, and the conditions of the atmosphere, which often rapidly changes on the same night. As an instance of the effect of the application of stops, I may mention that a 12-inch mirror that will not, in very unsteady air, divide γ Leonis with the whole aperture, will frequently under the same circumstances divide it very easily with an 8-inch stop.

Sometimes even a stop of an inch less than the full aperture will make a remarkable difference.

Judgment must, however, be exercised so as not unnecessarily to reduce the working aperture, as doing so is attended with the striking disadvantage that, while the sharpness and steadiness of star-discs is improved, the diffraction rings, which always surround the discs, are increased in number and thickness.

This result is due to the large amount of the field of the mirror the flat interferes with, in proportion to the remaining aperture.

From want of the requisite knowledge to enable them to apply stops when they are necessary, many persons are dissatisfied with the performance of mirrors of moderate or large aperture; they blame the mirror for not performing well, when it has only failed from disturbing atmospheric causes.

Well-known observers have expressed the opinion that the nights in this country are very few in which a greater aperture than 8 inches can be used successfully. But when the air is steady and a power of say 500 can be used with the whole aperture of a 12-inch mirror, the views of celestial objects will richly reward the possessor of such an instrument.

TO ADJUST AN EQUATORIAL.

To correct the Index error of the vernier of a Declination Circle.

Take any star near the meridian—that is, not more than 10° from the south, note the declination of this star, with the declination circle towards the east; now take the declination of the same star with the declination circle towards the west, subtract the lesser reading from the greater, halve the difference, and alter the vernier this amount; if this is successfully done, on repeating the readings, the star should give the same results whether the declination circle be placed east or west; should this not be the case, repeat the process, halving any small residual error, until the readings on both sides correspond; unless the readings can be made to correspond within at the utmost, one or two minutes, it will be useless to go any further with the adjustment.

To adjust the Polar Axis to the altitude of the Pole.

Take any star within 10° of the meridian (the nearer the meridian the better), and between the zenith and 45° from the horizon: read off the declination of this star on the declination circle, note whether this declination agrees with the declination of the star, as given in a star catalogue in the *Nautical Almanac*, if not, alter the adjusting screws which regulate the height of the polar axis, until the declination of the star shewn on the circle of the instrument, corresponds with the correct declination.

To set the Polar Axis in a line with the Meridian.

Take a star as nearly as possible due east or west, read off the declination of this star, should the reading not be correct, move the whole instrument round in azimuth, in such a direction as to cause the readings to come nearer and nearer to the true declination as shewn by a star catalogue. If the star is to the east of the meridian, and the instrumental reading is greater than the apparent polar distance, the north pole of the instrument requires to be moved towards the east, and *vice versa.*

To adjust the index of the hour circle to zero, when the

telescope is in the meridian, set the declination axis, horizontal by means of the sliding level on which the Vs. rest on the turned portions of the polar axis, having done this, set the verniers to zero, or a better plan is to find the time of southing of a star or planet from the almanac, and when this star is in the centre of the field of view, with a moderately high power, to adjust the verniers to zero and clamp them.

There are three other adjustments will require to be made, and an allowance will also have to be made for the error caused by refraction in the atmosphere, if the greatest nicety is required; but if stars be chosen in the positions named, these errors will never amount to more than a minute, as the equatorial is never as a rule used for absolute determinations, such a minute error may be neglected. For fuller instructions, see Chambers' Handbook of Astronomy.

ON VIEWING THE SUN.

To observe the Sun with any of the instruments described in these pages, some properly constructed eye-piece *must be used*, such as will give the observer the definition due to the aperture of the mirror; but intercept nearly all the light and heat of our great luminary.

Any neglect of this precaution may cost an observer the loss of his eye-sight, as even the smallest reflector I make will melt coloured glass placed outside the eye-piece such as is generally sent to screen the eye with small achromatic telescopes.

ON PRESERVING THE SILVER SURFACE OF THE SPECULUM.

Several methods, depending on the employment of deliquescent chemical substances, have been proposed for preventing the silver surface from becoming tarnished. These methods are troublesome, and sometimes do more harm than good. Practically, I find it quite sufficient to keep the speculum covered with a tightly-fitting cover, when not in use; and with such a cover all mounted specula should be provided.

It is a good plan to envelope the telescope, when not in use, in a cover made of American leather cloth. Should the

speculum be left in its place, this covering serves to protect the silver film, and under any circumstances, it will serve to keep dust out of the instrument. If, in spite of precautions, a deposit of moisture should take place on the speculum, or rain be allowed to fall on its surface, the mirror should be placed in front of the fire, taking care not to make it too hot, and kept there until the moisture has evaporated, and the surface become perfectly dry. If any stains should be left, they may be removed by polishing in small circular strokes, as in Fig. 11, with a rouged leather pad, first letting the mirror cool. The pad should be warmed and let to cool before using.

No matter how bad the surface of the mirror may appear, if these instructions be carefully followed, it may be restored to its original brilliant condition, but *if the moistened surface be rubbed before it has become perfectly dry, the whole of the silver surface will be removed.*

After some eleven years' constant experience in the use of these telescopes, I can assert that nearly all that has to be done, is to carefully *let the silver coating alone.* Several of my friends have mirrors which have been in use for four or five years, and they are almost unchanged in appearance, quite so in performance. There is no necessity to envelope the whole telescope tightly, if left in the open air; indeed, it is better not to do so. The peculiar laws of radiation and condensation cause the instrument to be more injured by doing this. A loose fitting, which protects it well from wet falling directly on it, is all that is required.

As regards the preservation of the surface of the speculum, all I do myself is to take out the large mirror in its cell (this can be done without altering the adjustments), and place on it the brass tight-fitting cover; it will be sufficient to replace the whole in the tube, and in this way, many specula remain uninjured year after year.*

A small brass cover is provided, which can be slipped on over the diagonal plane without removing it, or altering its adjustments.

* Reflectors above 8½ inches in diameter can be made with a door in the lower part of the body for the purpose of covering and uncovering the mirror without removing it from the tube.

The silver surface should not be polished more than once in six months at the utmost.

The speculum should not be taken from the cold air to a warm room, or when this cannot be avoided, the cover should be placed on the speculum while it is in the open air, or cold place, and the speculum and cell put in a box with a well-fitting cover, sent with the telescope, before it is removed to the warm apartment. This will prevent a disposition of moisture.

When carefully used the silver surface should last without renewal for three or four years.

An Observing Chair for use with Reflecting Telescopes of the Newtonian Construction.

This observing chair is made principally from suggestions I have received from Mr. Knobel. I have, however, at his kindly expressed wish, introduced several modifications which he thinks will add to its usefulness, before bringing the contrivance forward for practical use.

The seat A, on which the observer sits astride, is rather more than counterbalanced by two weights attached to cords which hang from pulleys at the top of the uprights, and the weights run down the uprights B B, which are made hollow for the purpose; the chair is always locked automatically, but can be released by the observer clasping either of the small metal handles C C, underneath the main bar at the top which moves with the seat. On releasing the cams by means of either of these handles, and simply raising himself from the seat, by resting his feet on the projecting brackets D D D D, the seat will itself rise in position, while by allowing his weight to rest gently on the seat while either of the cam levers are held, he can lower the seat to the full extent of the actions.

Appendix I.

TO SILVER GLASS SPECULA.

Prepare three standard solutions :—

Solution A	Crystals of Nitrate of Silver, 90 grains Distilled Water ...	90 grains 4 ounces.	Dissolve.
Solution B	Potassa, *pure by Alcohol* Distilled Water ...	1 ounce 25 ounces.	Dissolve.
Solution C	Milk-Sugar (in powder) Distilled Water ...	$\frac{1}{2}$ ounce 5 ounces	Dissolve.

Solutions A *and* B *will keep, in stoppered bottles, for any length of time; solution* C *must be fresh.*

THE SILVERING FLUID.

To prepare sufficient for silvering an 8-inch speculum :—

Pour 2 ounces of solution A into a glass vessel capable of holding 35 fluid ounces. Add, drop by drop, stirring all the time (with a glass rod), as much liquid ammonia as is *just* necessary to obtain a clear solution of the grey precipitate first thrown down. Add four ounces of solution B. The brown-black precipitate formed must be *just* re-dissolved by the addition of more ammonia, as before. Add distilled water until the bulk reaches 15 ounces, and add, drop by drop, some of solution A, until a grey precipitate which does not re-dissolve after stirring for three minutes, is obtained, then add 15 ounces more of distilled water. Set this solution aside to settle. Do not filter.

When all is ready for immersing the mirror, add to the Silvering Solution 2 ounces of solution C, and stir gently and thoroughly. Solution C may be filtered.

TO PREPARE THE SPECULUM.


Fig. 8.

Procure a circular block of wood 2 inches thick and 2 inches less in diameter than the speculum. Into this should be screwed three eye-pins, at equal distances, thus:—(Fig. 8). To these pins fasten stout whipcord, making a secure loop on the top.

Melt some soft pitch in any convenient vessel, and having placed the wooden block face upwards on a level table, pour on it the fluid pitch, and on the pitch place the back of the speculum, having previously moistened it with a thin film of spirit of turpentine to secure adhesion. Let the whole rest until the pitch is cold.

TO CLEAN THE SPECULUM.

Fig. 9.

Place the speculum, cemented to the circular block, face upwards, on a level table, pour on it a small quantity of strong nitric acid, and rub it gently all over the surface with a brush made by plugging a glass tube with pure cotton wool (Fig. 9). Having perfectly cleaned the surface and sides, wash well with common water, and finally with distilled water. Place the speculum, face downwards, in a dish containing a little distilled water until the silvering fluid is ready.

TO IMMERSE THE SPECULUM.

Fig. 10.

Take a circular dish about 3 inches deep, and 2 inches larger in diameter than the speculum. Mix in it the silvering solution and the solution C and suspend the speculum, face downwards in the liquid, which may arise about ¼ of an inch up the side of the speculum.

When the silvering is completed * remove the speculum from the solution, and immediately wash with plenty of water, using at least 2 gallons, and finally with a little distilled water. Place the speculum on its edge on blotting paper to drain and dry (Fig. 10).

Fig. 11.

When perfectly dry, polish the film by gently rubbing first with a piece of the softest wash-leather, using circular strokes (Fig. 11.), and finally with the addition of a little finest rouge.

A "flat" may be silvered by fastening with pitch to a slice of cork, cleaning as above described, and using as much silvering fluid as will form a stratum about ½ inch deep beneath the mirror.

TO SEPARATE THE SPECULUM FROM THE BLOCK.

Stand the speculum on its side, insert the edge of a sharp half-inch chisel between the wood and glass, administering two or three gentle blows, and the block and mirror will separate safely and easily. It is preferable to obtain the aid of an assistant in this operation. Any pitch which remains on the back of the mirror may be removed by scraping, and a little turpentine.

The cost of silvering an 8-inch speculum, exclusive of the cost of alcohol, which may be used over and over again, will not exceed 9d.

Nitrate of Silver being 4s. per oz.

Potash................8d.

Milk-Sugar..........2d.

Avoid all excess of ammonia, and be sure to use *pure* distilled water.

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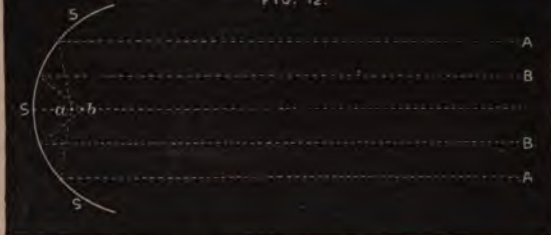
* The silvering will be completed in from 60 to 90 minutes, according to temperature 60 minutes will be sufficient in summer.

Appendix II.

ON WORKING GLASS SPECULA.

WHEN parallel rays of light are allowed to fall upon the surface of a concave mirror, if the surface be a spherical curve, the rays will not all be reflected to a single point.

FIG. 12.



In Fig. 12 it will be seen that the rays A falling on the mirror, would be reflected and form an image at *a*; while the rays B B would be reflected and form an image at *b*, farther from the front of the mirror.

If the reflected images were viewed with an eye-piece placed anywhere in front of the mirror, they would not be in focus at the same time, so that only a blurred and indistinct image would be seen.

To make the mirror reflect rays falling on all parts of its surface to one point, it is necessary that it should be fashioned into a parabolic curve, as in Fig. 13.

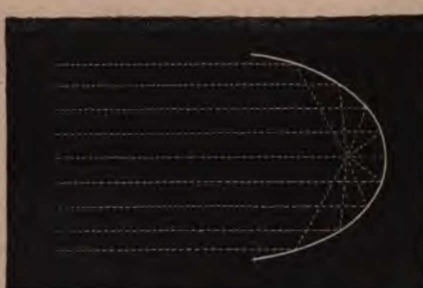


Fig. 13.

Such a curve is also shewn in Fig. 14, which may be considered as a spherical curve, in which the curve has been made deeper, or the outer portion flattened. In practice, the amount of this difference is so exceedingly minute as to be inappreciable by actual measurement.

Sir John Herschel states that the utmost variation of a four-foot speculum from a spherical curve is less than one 21,000th part of an inch. Yet it is well known that for telescopic use a mirror with a spherical curve is, for the reason just explained, totally useless.

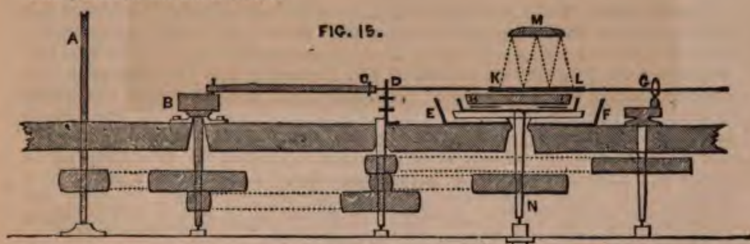
In working the glass specula, a disc of hard crown glass, varying in substance from three-quarters of an inch to one and a half inches,

according to the size of the speculum for which it is intended, is turned, and polished on the edge. One side of this disc is ground to a truly plane surface. On this side the speculum, when mounted on the writer's plan, rests in its cell. The other side is then ground to a concave spherical curve of such a radius as will produce the desired focus. This spherical curve is converted into a parabolic figure somewhat thus :—

An iron tool, similar to that on which the spherical curve has been ground, is covered with a layer of pitch, tempered to a certain consistency. This pitch is warmed, and the speculum being laid upon it, makes the pitch assume the same curve. The speculum is then polished on the pitch with rouge. In this polishing, the speculum and polisher are not worked together equally all over the surfaces, but the speculum is moved in such a manner that it is polished away most towards the edge, and a parabolic curve is produced. During the process, both the speculum and the polisher continually revolve.

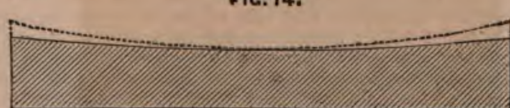
The diagram of Lord Rosse's machine, with which he figured his speculum six feet in diameter, will give an idea of the action of the speculum and polisher on each other.*

FIG. 15.



This machine is represented in Fig. 15; A is the spindle, by turning which the whole machine is set in motion; H I is the speculum; K L the polisher; B an eccentric which carries the polisher backwards and forwards; G another eccentric which moves the polisher from side to side slowly during the reciprocating motion. The amount of motion given to the polisher, and the rapidity of rotation of the speculum, can be changed at pleasure.

FIG. 14.



In Fig. 14, the dotted line represents the spherical curve of the mirror when the polishing is begun, and the continuous line the parabolic curve it assumes when the polishing process is finished. It will be of course understood that, in all the diagrams, these curves are enormously exaggerated.

During the graduated polishing, the speculum is repeatedly tested, until the desired definition is attained. When completed, if accurately figured, the marginal inch of the speculum should give equally sharp definition with the centre, and have identically the same focus.

In figuring the mirrors of the telescopes herein described, an improved method has been adopted of fashioning the parabolic curve: it is believed this method gives superior results to any hitherto attained.†

* This diagram is copied from Sir John Herschel's work on "The Telescope."

† The reader who wishes for further information on this subject is referred to the Treatise by W. Lassell, Esq., F.R.S., on Figuring Specula, reprinted from the Philosophical Transactions.

NOTICES WHICH HAVE APPEARED OF THE NEW TELESCOPES.

In the means of suspending the small mirror, the suppression of a great part of the thickness of the arm tends to do away with the rays which we all know appear to shoot out from the image of a star in the reflector.—

WARREN DE LA RUE, Esq., F.R.S., as President of the Royal Astronomical Society.

Mr. BROWNING exhibited a silver-glass speculum equatorially mounted in a very handy form.—ASTRONOMICAL REGISTER.

These two contrivances of Mr. Browning—the methods of mounting the speculum and the support for the diagonal plane mirror or prism—appear from the trials given to them in Mr. Slack's telescope to answer their purpose exceedingly well.

The President of the Astronomical Society expressed a doubt whether the cellular plan of mounting the mirror would answer for large instruments, but if it performs well up to seven, or eight, or ten and a quarter inches, the last being the largest size to which Mr. Browning has yet adapted it, its importance will stand very high. The new system of mounting the prism or flat has great advantages. The three slender springs do much less optical mischief than the single stout arm previously employed, and contribute with the excellent working of Mr. With's mirrors to remove the defective definition which reflectors usually give of large stars. In Mr. Slack's instrument the definition closely resembles that of a fine refractor, and the discs are remarkably small. In this equatorial stand, the special ends in view were great stability with convenience and economy.

Hitherto moderate priced stands have usually been of comparatively slight construction, and though many of them possess considerable merit, none of them seem adapted to carry a somewhat heavy and bulky telescope. It will be seen from the drawing that the base of the new stand is very compact and solid; it is in fact a stout cast-iron tube. The circles are twelve inches in diameter, reading to one minute of an arc, and 2½ minutes of time. The declination circle has considerable weight, and thus effectively assists in counterpoising the telescope. The tube of the telescope divides into two parts, each furnished with a flange fastened by screws to stout rings, supported by a heavy arm; by this means the principal weights are exactly opposite each other in every position of the instrument, and they are kept near the centre of the polar axis, and at about equal distances from the centre of gravity of the pillar stand. The hour angle motion has bearings equal to the diameter of the hour circle, twelve inches, which adds to the stability. Upon trial this telescope is found to be remarkably steady and free from vibration under a power of between 600 and 700, and the result of this steadiness is very conspicuous in the definiteness of the division of double stars, when the lowest powers are employed that can produce such a result.

The eye-piece or prism, or flat, revolve so that the awkward positions to which an observer is subjected when an ordinary reflector is mounted equatorially, are completely obviated. That these silvered glass telescopes will come into favour cannot be doubted, as they cost only a fraction of the price of refractors, capable of doing the same work, and perform to the satisfaction of performers like Mr. Webb—who has tried a good many—Mr. Cooper Key, and others.—INTELLECTUAL OBSERVER.

TESTIMONIALS.

It has hitherto been the writer's practice to refrain from publishing any testimonials he has received respecting the performance of his instruments, but at the suggestion of many friends, he is now induced to depart from this rule; but little is known of the performance of reflectors, and that little is probably unsatisfactory, their introduction has, therefore, met with many obstacles, on the score of prejudice, although the demand for these instruments is plainly increasing, still their possessors are so few, and so far apart, that it is not easy to obtain the opportunity of personally testing their performance.

The following Testimonials have been selected from a very large number the writer has received, in almost every instance they have been sent by experienced observers, who had previously been in the habit of using Achromatics of tolerably large aperture.

From the Astronomer Royal.

The Royal Observatory, Greenwich,
October 5th, 1868.

SIR,—I have just received a letter from Major Tennant, regarding his instruments, with which he seems to have been extremely well satisfied; in speaking of the large Telescope (a 9⅓ Equatorial Reflector) he says he was surprised at the steadiness, and the freedom of motion, and the facility of adjustment. The Photographing arrangements were most satisfactory.

I am, SIR,
Your obedient Servant,
(Signed) G. B. AIREY.

Mr. JOHN BROWNING.

24, Fairfax Road,
Feb. 4th, 1872.

My Dear Sir,—I must congratulate you and Mr. With on the exquisite definition of your 9⅓ in. Reflector. It is the best plea for Reflectors I have seen.

Yours very truly,
J. NORMAN LOCKYER.

Mr. JOHN BROWNING.

Rugby, November 9th, 1874.

My Dear Sir,—You might possibly care to know that on Saturday night last, being particularly clear and steady, I most distinctly and beautifully divided δ Cygni, with the 6½-inch Reflector, using your E and F Eyepieces. The division was so clear that had I possessed a micrometer I could have taken the distance with great accuracy. To prevent every chance of mistake, I went down to the Temple Observatory and had a look at the star with the fine 8¼-inch Achromatic, but I saw nothing that I had not seen, as I thought, equally well with my own instrument. Mr. Webb mentions that δ Cygni has been divided with a 9⅓-inch "With."

Believe me, yours very truly,

T. N. Hutchinson.

Girl's High School,

Dunedin, New Zealand.

My Dear Sir,—I am extremely delighted with the 8½-inch Reflecting Telescope you sent me. I find that in our damp climate it requires care, but if this be taken the instrument is a perfect treasure, with a power of 356 I see perfectly γ Centauri, π Lupi, ε Chamæleontis, γ Lupi, at present a very close double I have not yet quite split, but I have no doubt I shall be able to do so when the star is more favourably situated.

The Views of the "Sights" of the Southern Circumpolar Sky are magnificent. A Crucis and β Crucis, δ Centauri, and the planetry nebula in the Centaur, 47 Toucani, and the cluster including κ Crucis, the great Nebula in Argo, 30 Doradis, ω Centauri, these are simply marvellous. Nothing would induce me to part with the telescope, unless, indeed it might be for a larger one of your manufacture.

April 16th, 1875. James H. Pope.

The Hague,

27th June, 1875.

My Dear Sir,—And now to come to my 9½-inch Reflector, I can only say that it is a most beautiful instrument, doing more than I had expected, I could fill pages with my notes, but what I have seen you have seen hundreds of times, I only wish to quote that I have been able with the whole aperture to see details of the moon with power 600, as if I had moulded these craters, cracks, &c., with my own hand with plaster of Paris, 306 and 480 were generally used for definition of details.

Jupiter and his Satellites were simply exquisite, I generally used power 85 with the whole aperture, and 125-200 and 250 on occasions with reduced apertures of 8 or 9 inches.

Mars is for the moment out of question, due to his low altitude, and my limited sky-light in that way. Since I wrote you last I had not much good observing weather, and have often to reduce my aperture to 7 inches for stars and nebulæ, but never mind, I know what to look for, and see it thus perfectly with reduced apertures and low powers. It is not given to every one to observe, one must be accustomed to his instrument and know how to manage it.

Yours truly,

A. de Bourbon.

Burton-on-Trent,

June 11th, 1873.

Dear Mr. Browning,—The Telescope has given me some astonishing views, I never imagined I should get such splendid views of Mars as I have on one or two nights, my only regret is my utter inability to depict all I could see. One feature in the Kaiser sea I have particularly noticed, viz., some peculiar dark markings in the " Hour Glass."

Believe me, faithfully yours,

E. B. Knobel.

From the Owner of a 9¼-inch Reflector.

3, Circus Road, St. John's Wood, N.W.,

February 10th, 1872.

Dear Mr. Browning,—I am delighted with the instrument; its definition is beyond the power of my eye to see. I feel that there is much more than I can define with the pencil, but I shall get used to it by degrees.

Yours respectfully,

(Signed) N. E. G.

Burton-on-Trent,

July 12th, 1871.

My Dear Sir,—Every night I can use the Telescope (an 8½-inch Reflector), I am more and more delighted with it. The difficult test object β Equuli, which was almost more than Smyth could do, my Telescope shows me at once with ease. I had four hours with Nebulæ and Clusters last night, and the views I got were superlative.

Believe me, yours faithfully,

(Signed) E. B. K.

Mr. John Browning.

Another Letter from the same Writer.

Burton-on-Trent,

July, 1871.

My Dear Sir,—Last night, after a showery evening, at midnight, the atmosphere was quite calm and steady, η Coronæ, with 200 was easily divided, the discs remarkably small, and the minute Stars between ϵ and 5 Lyræ, the Dibilissima were large and bright, and the third minute Star, rated I believe at the 16th magnitude, was plainly seen, and, as well as my recollection serves me, nearly as bright as I saw it in Mr. Lowe's 8¼-inch Alvan Clarke. At 1.30 this morning I tackled $\gamma 2$ Andromeda. After a longer steady gaze I am perfectly satisfied I divided it with 300. I sketched the apparent position of the components, and on afterwards taking out their position from Smyth's cycle, and comparing with Dawe's drawing, I am confident I was not mistaken.

I can only assure you how pleased and satisfied I feel at this result. The views I have had of the Stellar objects, 57m. 13m. 3m. and 17m. were simply exquisite.

Yours faithfully,

(Signed) E. B. K.

Mr. John Browning.

Earith, St. Hives,
January 2nd, 1869.

DEAR SIR,—I have been for some time engaged in testing my Reflector (a 9¼-in. Alt-azimuth) with reduced apertures, γ^2 Andromeda is so well divided with 9 in. that I have distinctly seen and noted the contrasted colours with a power of 320.

Yours faithfully,

Mr. JOHN BROWNING. (Signed) J. T. B.

27, Sumner Hill, Dublin,
July 13th, 1869.

MY DEAR SIR,—The 8½-in. mirror is all it professed to be—of most perfect figure and defining power. Last night at 1.30 A M., I obtained a most beautiful view of Saturn, many of the tints shewn in your coloured print beginning to shew themselves, especially the azure blue of the poles—there was a slight haze, and the air was very still, and allowed me to use the highest power I have, 356.

Yours very truly,

Mr. JOHN BROWNING. (Signed) S. T.

Another Letter from the same Gentleman.

27, Sumner Hill, Dublin,
July, 1869.

MY DEAR SIR,—The Mirror has turned out far better than even in my most sanguine moments I could have anticipated, every good evening when the air is fine and clear, some new proof of its extreme excellence compels me to thank you afresh. On the evenings of the 29th and 30th of June, and 1st July, I tried it on many difficult double Stars, and succeeded most perfectly with them, η Coronæ was clearly split with a power of 178, shewn well apart with 300, and quite wide with 350, the discs being beautifully clear and pure on the three evenings. I turned to μ^2 Bootis, on applying a power of 300 it was evidently divided at intervals, and very much elongated at all times, this division became steady and beautifully defined with a power of 350, remaining so through all the night, whenever I turned the Telescope to it, which I did again and again to satisfy myself and others who were observing with me of its permanent character. The feat was readily accomplished on the two succeeding nights.

Believe me, yours very truly,

Mr. JOHN BROWNING. (Signed) S. T.

Wynyard Square, Sydney, N. S. Wales,
January 27th, 1871.

SIR,—I have much pleasure in stating the Telescope (an 8½-inch Reflector) has given great satisfaction, and I consider it in many respects superior in optical performance to the Refractor at the Sydney Observatory (a 7¼-inch, by Merz). This conclusion has been arrived at after several comparisons on the same objects, both by Mr. Russell (the Government Astronomer) and myself.

I am, SIR, yours faithfully,

MR. JOHN BROWNING. (Signed) H. G. W.

Another Letter from the same Writer.

Sydney, February 26th, 1872.

My Dear Sir,—I am able to see with my 8¼-inch Reflector, nearly, if not all of the great Nebula in Argo, that can be seen with the great Melbourne Equatorial.

I am, My Dear Sir, faithfully yours,

Mr. John Browning. (Signed) H. G. W.

Rugby, November 13th, 1871.

My Dear Sir,—I have seen enough of the work of the instrument (a 6½-inch Equatorial Reflector) to be quite assured of its merits. On Friday and Saturday nights, I could distinctly divide γ^2 Andromedæ during occasional moments of steady air. I had some boys with me who knew nothing of the Stars, and they described to me the exact position of the second Star. My 6½-inch showed the Comet nearly as well as the 8¼-inch Refractor in the Temple Observatory. One of the most satisfactory proofs of the excellence of the 6½-inch is, I think, the fact that it suffers nothing by comparison with the fine 8¼-inch Achromatic.

Yours faithfully,

Mr. John Browning. (Signed) T. N. H.

THE REV. T. W. WEBB, F.R.A.S.,

IN

"Intellectual Observer."

Feb. 1867.

The speculum—though its figure has not received its final touch—gives very sharp and clear definition and separates γ^2 Andromedæ with great ease.

March, 1867.

On re-examining R. Leonis, with a 9½ silvered glass speculum, by With, 1897, February 2, I found the colour very fine.

May, 1867.

I now see it (the gaseous Nebula in Hydra) with my 9½ mirror as a very brilliant object.

June, 1867.

The cluster in Canes Venatici. Its recent aspect with a 9½ silvered speculum was different indeed. There the resolution is carried very far.

53 M. The 9½-inch mirror masters it.

December, 1867.

The possession of the beautiful figured 9½ "With" Speculum already alluded to leads to the addition of the two following objects as tests for those who may be equally fortunate in optical means.

1. 8 Cygni (delta Cygni.)

This extremely difficult test I have seen so fairly with 450 in only a moderately favourable state of the air and at a comparatively low elevation, that it may be inferred to be easy under really advantageous circumstances.

2. μ Andromedæ (Mu Andromedæ); the 4th mag.: Star next nϕ B, in the line pointing upwards to the Great Nebula. This has a companion at 45″ and 115°, 16 mag., which is consequently as severe a test of light as the previous pair is of definition. It is so minute that Smyth saw it but once with his 5.9-inch object glass, and when the larger star was hidden by a bar in the field.

This most delicate point I have caught up without much trouble, and that while from a mistake as to the angle I had so little expectation of seeing it where I found it, that I had been diligently gazing at a spot 90° distant. It was but just steadily visible but showed itself in the full presence of its blazing companion, so that it may be fairly inferred that this Telescope reaches 17, at any rate of the 20 magnitudes grasped by the 18-INCH front view of H's metallic mirror. It may be mentioned that this Speculum, which, however fine, can at any time be equalled, if not surpassed by its truly successful maker, shows a black division, with 450 between the components of γ^2 Andromedæ, and, with a lower power, traces for a long distance both of the remarkable "canals" or rifts in the Great Nebula in the same constellation.

The following Prices are Nett for Cash, half-price allowed for returned Packages, if Carriage Paid.

Orders should be accompanied by a remittance.

LIST OF PRICES,

April, 1876.

SILVERED GLASS TELESCOPES and SPECULA.

SILVERED GLASS SPECULA, UNMOUNTED.

WITHOUT CELLS.

The performance of these specula will be guaranteed; they will bear a power of 100 to the inch on suitable objects and under favourable conditions of the atmosphere.

	£	s.	d.
Speculum 4¼ inch diameter, about 5 ft. focus	5	0	0
" 6¼ " " 5 "	9	7	0
" 8½ " " 5 "	17	12	0
" 9¼ " " 6 "	23	2	0
" 10¼ " " 6 "	38	10	0
" 12¼ " " 6 "	55	0	0
" 13 " " 9 "	82	10	0
" 15 " " 10 "	110	0	0
" 18 " " 15 "	150	0	0

PRICES OF SILVERED GLASS SPECULA ASTRONOMICAL TELESCOPES, ON ALT-AZIMUTH STANDS.

	£	s.	d.
3½ inch speculum, 3 ft. focus, mounted in metal, on metal alt-azimuth stand, with two eye-pieces, 50 to 150	10	15	0
4¼ inch speculum, 5 ft. focus, mounted on a stand, which can be changed from alt-azimuth to parallactic, so that the stars can be followed with one motion, with endless driving screw, and hook joint and two eye-pieces, 100 to 200 (Fig. 5)..	24	4	0
6¼ inch speculum, 6 ft. focus, on alt-azimuth stand, with quick and slow fine screw motions, and three eye-pieces, 100 to 450 (Fig. 6)	36	6	0
8¼ inch speculum, 8 ft. focus, mounted as above, with three eye-piece, 100 to 300 (Fig 6)	49	5	0
9¼ inch speculum, 8 ft. focus, as above, with four eye-pieces, 100 to 600 (Fig. 6)	59	10	0
10¼ inch speculum, 9 ft. focus, ditto (Fig. 6)	79	6	0

SILVERED GLASS SPECULA ASTRONOMICAL TELESCOPES,

EQUATORIALLY MOUNTED IN A SUPERIOR MANNER.

	£	s.	d.
4½ inch speculum, 5 ft. focus, equatorially mounted (angle for latitude to order), with 6 inch hour circle reading to 5 seconds, and declination circle reading to 1 minute, two eye-pieces, 100 and 300 (Fig. 7)	49	10	0

	£	s.	d.
6½ inch speculum, 6 ft. focus, with 12 inch hour circle reading to 5 seconds, and declination circle to 1 minute, three eye-pieces, 100 to 450, rotating hour circle	88	0	0
8½ inch speculum, 8ft. focus, mounted as above	115	10	0
9¼ inch speculum, 8 ft. focus, with four eye-pieces 100 to 600 ..	148	10	0
10¼ inch speculum, 9 ft. focus	181	10	0
12¼ inch speculum, with extra eye-pieces	242	0	0
13 inch speculum, with ten eye-pieces, including Achromatics and Kellner	368	10	0
15 inch speculum, 10 ft. focus, with 16 inch hour circle, reading to five seconds and declination circle to one minute, with three Huyghenian eye-pieces, one Kellner, and six Browning's improved Achromatic eye-pieces, powers ranging from 60 to 600 diameters. Position Micrometer, with two verniers divided on silver, and reading to single minutes, with clock-work driving apparatus complete ..	650	0	0
Clock-work driving apparatus to 8½, 9¼, or 10¼ inches	38	0	0
Ditto ditto 12½ or 13 inches	49	0	0

These instruments can be furnished with reflecting prisms of the finest quality, in place of the diagonal mirrors generally used; but silvered planes are recommended and supplied as giving the finest definition. When planes are chosen, two of the choicest quality will be sent with each instrument.

SILVERING GLASS SPECULA.

	£	s.	d.		£	s.	d.
4½ inches	£0	5	0	9¼ inches	£0	15	0
6½ „	0	10	0	10¼ „	1	0	0
8½ „	0	12	6	Diagonal Planes ..	0	2	6

All charges incurred for carriage will be extra.

ASTRONOMICAL EYE-PIECES—HUYGHENIAN CONSTRUCTION.

	£	s.	d.
Nos. 1 and 2, magnifying 65 and 85	£0	15	0
„ 3, 4, and 5 „ 125, 200, and 250	1	0	0
„ 6 „ 400	1	5	0
„ 7 „ 600	1	10	0

ACHROMATIC EYE-PIECES.

These eye-pieces have a rather limited field but their performance with reflecting telescopes, particularly on planets, is very superior to Huyghenian.

			£	s.	d.				£	s.	d.
A	Magnifying	86 ..	£1	2	6	E	Magnifying	306 ..	£1	15	0
B	„	144 ..	1	10	0	F	„	450 ..	2	0	0
B*	„	180 ..	1	12	6	G	„	600 ..	2	5	0
C	„	208 ..	1	15	0	H	„	840 ..	2	10	0
D	„	250 ..	1	15	0						

LARGE FIELD EYE-PIECES.

	£	s.	d.
Very low power comet eye-piece, magnifying 35	£1	0	0
Kellner eye-piece, with field of 50 minutes, for clusters or nebulæ, magnifying 60	1	7	6
Ditto, with field of 35 minutes, for clusters, nebulæ, or the moon, magnifying 85	1	7	6
Day-power eye-pieces, erect .. .. .. £1 0 0 to	1	10	0

The power of all these eye-pieces has been calculated on an object-glass, or mirror, of six feet focus.

SOLAR EYE-PIECES.

	£ s. d.
Single reflecting prism, mounted for viewing the sun or moon, with two shade heads, in mahogany case	3 10 0
Ditto, with two prisms, arranged for single reflections, for viewing the sun only	8 0 0
Browning's new solar eye-piece, single	4 0 0
Ditto, with two double prisms	8 0 0

TRANSIT EYE-PIECES.

Transit eye-piece, with fine webs or wires	1 5 0
Ditto, with 7 webs and higher powers .. £1 10 0 to	1 15 0

PARALLEL WIRE MICROMETER.

Micrometer for measuring to fraction of a second .. £6 to	11 11 0

POSITION MICROMETER.

	£ s. d.
Parallel wire micrometer, with position circle and two verniers, reading to single minutes	11 0 0
Ditto, superior make, divided on silver	13 15 0
Ditto, divided on platinum	17 0 0

Extra Eye-pieces, 15s. each.

Browning's Double image Micrometer	8 10 0

BARLOW'S LENS.

This is an achromatic combination of a negative focus; on inserting it behind any eye-piece (that is, between the eye-piece and the object-glass) the power of the eye-piece is increased from one-third to one-half; at the same time the introduction of this lens, especially when using Huyghenian eye-pieces, greatly improves the performance of reflecting telescopes, especially on bright stars.

Price of the best quality, £1 2 6

	£ s. d.
SMOKE-COLOURED GLASS WEDGES corrected for refracting for intensifying the marks on the moon or planets	1 2 0
NEUTRAL TINT WEDGES for observing the sun .. each	1 2 0
DIVIDED LENS DYNAMETER, for measuring accurately the power of eye-pieces, new movement for separating the lenses	4 4 0

ASTROMETER.

Knobel's Astrometer, a simple and efficient instrument for determining star magnitudes	12 10 0

PERFECT PLANES, UNMOUNTED.

PERFORMANCE UNDER ANY POWER GUARANTEED.

1 inch in the minor axis of the ellipse	1 0 0
1 " " "	1 10 0
2 " " "	2 0 0
2 " " "	2 10 0

Prepared pad for Polishing Specula, in bottle, 2s. 6d.

An Illustrated Catalogue of Spectroscopes sent post free for 18 stamps.
" " " Microscopes " " 7 "

ASTRONOMICAL WORKS.

	£	s.	d.
A New Star Atlas for the Observatory—12 Maps with letter-press—by R. A. PROCTOR, B.A., F.R.A.S.	1	5	0
Descriptive Astronomy, by F. CHAMBERS, F.R.A.S.	1	1	0
Celestial Objects, by Rev. T. W. WEBB, M.A., F.R.A.S., Second Edition	0	7	6
Elementary Astronomy, by J. N. LOCKYER, F.R.A.S.	0	5	6
Saturn and its System, by R.A. PROCTOR, B.A., F.R.A.S. ..	0	14	0
Half-hours with the Stars, by R. A. PROCTOR, B.A., F.R.A.S...	0	5	0
Half-hours with the Telescope, by R.A. PROCTOR, B.A., F.R.A.S.	0	2	6
Sun Views of the Earth, by R. A. PROCTOR, B.A., F.R.AS. ..	0	5	0
Other Worlds than Ours, by R. A. PROCTOR, B.A., F.R.A.S., Second Edition	0	10	6
Handbook of the Stars, by B. A. PROCTOR, B.A., F.R.A.S. ..	0	5	0
The Sun, by R. A. PROCTOR, B.A., F.R.A.S.	0	14	0

JUNE, 1876.

The following Prices are Nett for Cash; half-price allowed for returned Packages, if Carriage Paid.

JOHN BROWNING'S
PRICED LIST OF SPECTROSCOPES.

	£	s.	d.
The Charm Spectroscope, for wearing on a Watch Chain, either Gilt or Nickelised	2	10	0
The Minute Spectroscope, dimensions 2 inches long, ⅜ diameter	1	10	0
The Miniature Spectroscope, dimensions $\frac{7}{10}$ diameter, 3 inches long	1	2	0

These instruments will show many of Fraünhofer's lines, the bright lines of the metals and gases, and the absorption bands in coloured gases, crystals, or liquids.

Ditto, with ajustable slit (Fig. 1)	1	13	0
Morocco Case, extra	0	2	0
Ditto, with Achromatic Lenses, &c., &c., in Morocco Case ..	2	6	0
Ditto ditto, with small Reflecting Prism for obtaining two Spectra	2	12	0
Clip Stand for any of the above	0	12	6
New form Direct-Vision Spectroscope, with five prisms, fitted in Mahogany Case, 18 inches long	5	15	0

This Spectroscope is a most powerful and portable Direct-Vision Instrument, easily separating the D lines in the Solar Spectrum.

Ditto, higher dispersive power, and extra power Eye-piece, complete in Mahogany Case	6	18	0
Extra power Eye-pieces for the above .. .. .. each	0	12	6
Clip Tripod Stand, Portable, for above	1	15	0

CHEMICAL SPECTROSCOPES.

The Popular Spectroscope	5	0	0
The Student's Spectroscope, in Stained Cabinet (Fig. 2) ..	6	10	0
The Model Spectroscope (Fig. 3), with two Prisms, in Polished Mahogany Cabinet	15	0	0
The Model Spectroscope, with four Prisms, in superior Cabinet, with Fittings and two Eye-pieces	27	10	0
Browning's Automatic Action, extra	6	10	0
The Large Model Spectroscope for the use of Physicists, made on the plan of the Gassiot Spectroscope (Fig. 4)	38	10	0
Dividing ditto on Silver, extra	2	0	0
Browning's Automatic Action to the above, extra	12	10	0
The above Instrument, the circle divided on Silver to 20 seconds, with five Prisms, four Eye-pieces, and parallel wire Micrometer, for measuring the position of lines to $\frac{1}{10000}$ of an inch, the whole in Mahogany Case	55	10	0
Browning's Automatic Action to the above	15	0	0

Larger Spectroscopes to Order.

BROWNING'S NEW AUTOMATIC SPECTROSCOPE.

The Automatic Spectroscope, with six Prisms and six Eye-pieces, and Micrometer Eye-piece, in case complete (Fig. 5)	50	0	0
Browning's Universal Automatic Spectroscope, with six Prisms, best Filar Micrometer Battery of nine Eye-pieces in Mahogany Cabinet, with which any dispersive power may be used at pleasure, without deranging the adjustments of the instrument by means of the reversion of the ray. With this instrument a dispersive power, ranging from two prisms to twelve, can be employed	65	0	
Ditto, ditto, same size as large Model Spectroscope	150	0	

	£ s. d.
Browning's Automatic Solar Spectroscope. Price complete, with set of four Eye-pieces	42 10 0

By means of the reversion of the ray, this Spectroscope gives a dispersive power equal to 11 prisms, and this dispersive power may be changed at pleasure by the observer. It is well adapted for use with any Telescope, either a Reflector or Refractor, from 6 in. to 12 in. in aperture.

Browning's Automatic Solar Spectroscope. Complete in case, with Eye-pieces	28 0 0

By means of the reversion of the ray, this Spectroscope gives a dispersive power equal to 11 prisms, and this dispersive power may be changed at pleasure by the observer. This instrument is very light, and can be adapted to a Telescope as small as 3 in. in aperture. It is provided with a movement of rotation for searching for solar prominences.

Direct Vision Spectroscope, with adapter for Telescope, useful only for Solar researches	14 10 0
Adapter with movement of rotation for attaching the instrument to a Telescope	6 0 0

PRISMS.

Prisms of extra dense flint glass, of very superior quality, ¾ in., of 45 or 60 degrees and accurate plane surfaces	0 15 0
Ditto, 1 in., 20s.; 1¼ in., 30s.; 1½ in., 60s.; 2¼ in., 90s.; 2¾ in.	6 0 0
Ditto, 3 in., £15; 4 in. by 3 in.	30 0 0
Bisulphide of Carbon Prisms, large size .. .. .. each	0 15 0
Bisulphide of Carbon Prisms, with Parallel Glass Sides, Browning's improved method of mounting in Metal Frames each	1 15 0

PRISMS OF OTHER ANGLES TO ORDER.

STAR SPECTROSCOPES.

The Amateur Star Spectroscope, in Mahogany Case (Fig. 7) ..	4 0 0
Star Spectroscope, with one Prism, packed in Polished Mahogany Case	8 8 0
Star Spectroscope, with two Prisms, reflecting Prism to show two spectra at once, and Micrometer Measuring Apparatus for mapping spectra, packed in Polished Mahogany Case..	14 0 0
Star Spectroscope of the best construction, with adjustable reflecting Prism and Mirror, with finest object glass, Micrometric Apparatus for Measuring the lines of the spectrum to $\frac{1}{10000}$ of an inch, extra Eye-piece, and Ivory Tube to Reader of Vernier, as made for Dr. Huggins, F.R.S., packed in polished Mahogany Case, with insulated Spark Apparatus attached to Mirror, for obtaining the spectra of the metals for comparison (Fig. 6)	21 0 0

INDUCTION COILS.

Induction Coil, to give half-an-inch spark in dry air	3 10 0

Well adapted for working with Geissler's tubes, and obtaining the spectra of various gases by means of the Spectroscope.

Ditto, to give a 1-inch spark	7 0 0
Ditto, to give a 1½-inch spark	10 0 0
Ditto, to give a 2½-inch spark	13 0 0
Ditto, to give a 4½-inch spark, with Browning's Improved Break	18 0 0
Ditto, to give a 6-inch spark	25 10 0

Coils above 1-inch spark are adapted for deflagrating metals so as to obtain their spectra by the aid of the Spectroscope.

SPECTRUM APPARATUS FOR THE MICROSCOPE.

	£	s.	d.
The Sorby-Browning Micro-Spectroscope	5	15	0
Ditto ditto with Rack motion to Eye-piece (Fig. 14)	6	0	0
Browning's bright line Micrometer for measuring position of bright lines in spectra (Fig. 15)	2	5	0
Putting Rack motion to a finished £5 5s. instrument	0	15	0
Case for ditto, with Racks for Cells and Tubes	0	15	0
Sorby's Tubes .. .. per doz.	0	2	6
Sorby's Wedge Cells	0	6	0
Specimens in Sealed Tubes for showing the bands..	0	1	6
The Amateur's Micro-Spectroscope, with achromatic lens and reflecting prism, to show two spectra at the same time, for the purpose of comparison (Fig. 16)	2	15	0
Mahogany Case for the above	0	5	0

SUNDRY SPECTROSCOPIC APPARATUS.

Hollow Cells, with one side formed of a prism, for holding solutions for examining absorption bands	1	1	0
Large ditto, for projecting spectra on screen	1	11	6
Extra power Eye-pieces .. .. .. each 12s. 6d. to	1	0	0
Bunsen's Burners .. .. 3s. 6d. to	0	5	0
Adjusting Clip, on stand, to hold platinum wires	0	3	6
Browning's improved Spectroscope Lamp, containing burner and clip on a single stand, complete (Fig. 17)	0	12	6
Leyden Jars .. .. from 3s. 6d. to	2	2	0
Insulated Spark Apparatus, on brass stand, with two Dischargers for obtaining the spectra of metals, gases, and solutions ..	1	18	6
Browning's New Spark Condenser (Fig. 18)	3	0	0
Ditto, with shifting connections	3	15	0

A convenient substitute for the Spark Apparatus, and Leyden Jars, for burning metals for spectrum analysis.

Becquerel's apparatus for obtaining the spectrum of a substance in solution. A valuable addition to the above .. extra	0	15	0
Plucker's Tube Holder, for holding a Single Plucker's Tube ..	1	5	0
Plucker's Tube Holder, for holding 7 tubes	3	3	0
Insulated Spark Apparatus, on brass stand, for obtaining the Spectra of Metals	1	5	0
Insulated Spark Apparatus, with vertical and horizontal rack motions	1	15	0
Insulated Spark Apparatus, with 7 Dischargers for obtaining the Spectra of 7 metals without altering the apparatus	4	0	0
Ditto, with 14 Dischargers	6	10	0
Set of 13 chemically pure Metals, in Mahogany Cabinet, for Spectrum experiments	0	18	6
Plucker's Tubes, prepared for showing the beautiful Spectra of various Gases—Nitrogen, Hydrogen, Oxygen, Carbonic Acid, Ammonia, Sulphuric Acid, Olefiant, Chlorine, Bromine, Iodine, Coal Gas, Æther Vapour, Turpentine Vapour, and Petroleum Oil Vapour, each .. .. 5s. 6d., 7s. 6d.	0	8	6
Set of Salts best adapted for showing Chemical Spectra, stoppered bottles, in case	0	7	6

METALLIC THALLIUM AND OTHER CHEMICALS TO ORDER.

Platinum Wire for spectrum analysis .. .. per foot	0	1	0

April, 1876.

DESCRIPTION OF THE NEW AUTOMATIC ELECTRIC LAMP.

Fig. 1.

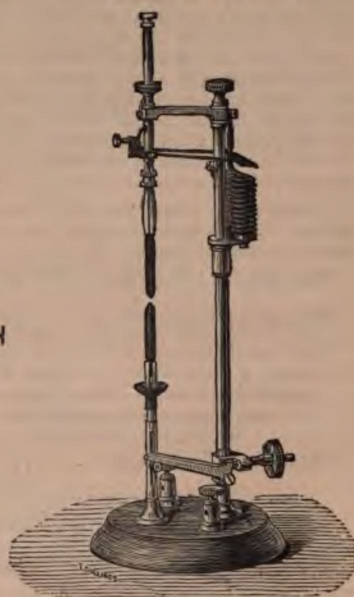


Fig. 2.

In the above engraving the carbon points are carried by the holders, A B, which are provided with rings like a porte-crayon, to clamp the points when in position. C D, is a soft iron feeder; the end, C, of this feeder is so arranged that a very slight pressure on the feeder clamps the rod B, and prevents it from descending. E is a rod of soft iron in the form of a horse-shoe: when the electricity passes through the wire wound upon this horse-shoe, the iron becomes a magnet, and attracts the feeder. F and G are clamping screws to clamp the sliding rods in any required position. H is a silvered parabolic reflector for throwing the light of the lamp to a great distance.

To Set the Lamp in Action.

Release the clamps, F G, place two pieces of fine hard carbon in the holders; the carbons should be well pointed; wipe the rod, B, with a leather, so that it may slide freely, then adjust the large central rod so that the extreme point of the upper carbon exactly rests upon the lower carbon. Attach the wire from the last plate of zinc in the battery to the lower carbon holder, and the wire from the plate of platinum at the opposite end of the battery to the upper carbon holder. If the light should not burn steadily, alter the position of the magnet by means of a small set screw between the ends; this screw is not shown in the drawing. The magnet must not be put close to the feeder; the best distance to place the magnet from the feeder is generally about half an inch, but this will vary with the power of the battery employed. When correctly adjusted, there should be no perceptible movement of the feeder.

Instructions for Charging the Battery.

Fill the porous cells with nitric acid—that is, commercial aquafortis—and insert the platinum foil or carbon plate. In a strong stoneware vessel, mix one part of oil of vitriol—that is, commercial sulphuric acid—with seven parts of water. Fill the outer cells with this mixture, having first introduced the zinc plates and porous cells. After the porous cells have been placed in the centre of the zinc plates, connect the platinum or carbon plate in each cell with the zinc plate in the next cell by means of the brass clamps; attach one of the clamps with the finger-screw at top, to the unconnected platinum or carbon plate at one end of the battery, and the other clamp of the same kind to the unconnected zinc plate at the opposite end of the battery; then connect these ends with the copper wires as before directed. The battery will not attain its full power under half an hour after charging. When the battery is done with, the porous cells, zinc, and platinum or carbon plates should be well washed in water. The porous cells should be allowed to remain in fresh water for several hours.

Occasionally, when the zinc plates are taken out of the acid, a little mercury should be well rubbed over them by means of a piece of rag tied round a small stick.

This should be done before they are washed in water.

	£	s.	d.
Price of the Lamp (Fig. 1)	2	5	0
Improved ditto, with adjustment for keeping the points of the burning carbons at one height, or separating them to any required distance, without Parabolic Reflector (Fig. 2) ..	2	15	0
This adjustment is indispensable for projecting the Spectra of Burning Metals on a Screen.			
Parabolic Reflector, extra	0	6	6

BROWNING'S NEW LARGE AUTOMATIC ELECTRIC LAMP.

(Fig. 3.)

Price £9 9s.

Parabolic Reflector, £2 2s.

In this Lamp both carbons are moved by electricity of the battery employed (without the aid of clockwork); the light remains uniform in height and more steady in action than any of the expensive regulators previously introduced. From 25 to 50 quart Grove's cells, or the same number of 2 quart Bunsen's, should be used with this lamp.

For a full description of these Lamps and their performance, see Rossiter's Physics, *or Dr. Atkinson's translation of* Ganot's Physics. *For other notices, see* Scientific Opinion, *Dec. 30th*, 1868; British Journal of Photography, *Oct. 30th*, 1868; *or the* Mechanics' Magazine, *Nov. 13th*, 1868.

Fig. 3.

	£	s.	d.
Carbon Rods for Burning in Small Lamp, per foot	0	1	0
Ditto, per dozen feet	0	10	0
Large Rods for Burning in the Large Lamp, per foot	0	1	6
Ditto, per dozen feet..	0	15	0
Carbon Cups for holding Metals to obtain their Spectra, per dozen .. .. small, 10s.; large	0	12	6

PRICES OF BATTERIES.

	£	s.	d.
Grove's Cells .. .. pints, 11s.; quarts	0	14	0
Bunsen's .. .. .. pints, 5s. 6d.; quarts, 6s. 6d.; 2 quarts	0	9	0
Varnished Oak Trays.. .. .. .. for 6 cells, 6s.; for 10 cells	0	10	6
Insulated Copper Wire, per yard .. .. 4d. to	0	1	9

BROWNING'S

SPECTRUM APPARATUS.

Fig. 4.

JOHN BROWNING has great pleasure in introducing to the notice of Lecturers and others a complete set of apparatus for projecting the spectra of metals, or the absorption bands of liquids, on a screen. The apparatus comprises an Automatic Electric Lamp and Lantern, with slit, battery, and tray, mounted focussing lens, bisulphide of carbon prism and stand, platform for the whole, and packing case.

	£	s.	d.
Price with 12 quart Bunsen's Cells (Fig. 4)	10	0	0
" " 20 " " "	12	10	0
Nozzles with lenses and 3½ inch condensers, for showing diagrams or views on screen, extra	2	15	0
Very complete and powerful set of Spectrum Apparatus, consisting of Browning's New Large Automatic Electric Lamp, *without clockwork*, Lantern for ditto, with slit arrangement; battery of 30 quart Grove's cells in tray; large focussing lens, mounted on stand; two bisulphide of carbon prisms on stand; platform for the lamp apparatus, and two packing cases	45	0	0
Nozzle with 4½ condensers, extra	4	15	0
Mahogany box, fitted with metals for burning in the electric arc, carbon crucibles, and pliers	2	10	0

Illustrated Catalogue and Description of Spectroscopes sent for 18 stamps.

	£ s. d.
Electric Lantern for Large Lamp, mahogany body, tin lined arc casing, with brass rack-work, nozzle, and 3½ inch condensers	7 10 0
Improved Lantern, the body of brass, bronzed, with two nozzles, specially arranged for exhibiting spectra or diagrams on the same screen without shifting the lantern or re-arranging the apparatus, with 3½ inch condensers (Fig. 5)	11 10 0
Ditto, ditto, larger size, and 4½ inch condensers	16 10 0

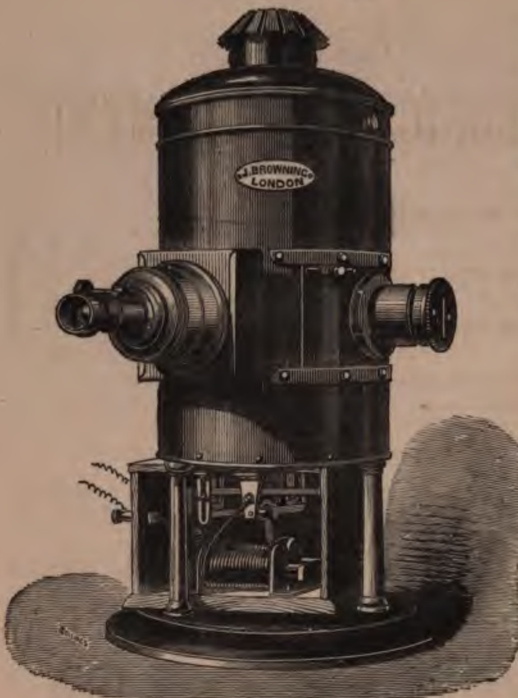


Fig. 5.

TO LECTURERS ON SCIENCE.

JOHN BROWNING begs to announce that he has prepared, with peculiar care, a great number of Diagrams to illustrate recent discoveries in Spectrum Analysis, and other branches of Observational Astronomy. These Slides can be had either plain or exquisitely coloured. Prices—3s. 6d. plain; and from 4s. 6d. to 10s. 6d. coloured. A list of subjects priced on application. Photographs of Microscopic Objects, for the Lantern, 3s. each. Landscapes, Copies of Pictures, Drawings by Gustave Doré, &c., &c. Lists on Application.

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Small-sized Electric Lamp and Lantern, either for Spectrum Analysis or Diagrams on Screen, £2 2s. in town, £3 3s. in country. Large-sized ditto, with Browning's new large Automatic Electric Lamp and improved form of Lantern, £5 5s. in town, and £7 7s. in country.

These charges are for three clear days: an additional charge of one-half more will be made for each three additional days the apparatus may be kept. Assistant's expenses extra.

For terms of hire of Lanterns, Diagrams, and Slides, plain or coloured, see separate list.

JOHN BROWNING,

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To Her Majesty's Government, The Royal Society, The Royal Observatories of Greenwich and Edinburgh, and the Observatories of Kew, Cambridge, Durham, Utrecht, Melbourne, &c., &c.,

63, STRAND, W.C.

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LIST

OF

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Window Thermometer, ivory scale, to be fixed outside a window, and show the temperature from inside the room 8-inch 15/, 9-inch 17/6, 10-inch	1	4	0

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	£	s.	d.
Garden or Greenhouse Thermometer, box scale ...	0	1	6
Ditto, ditto, ditto, self-registering to show the greatest degree of cold, with metal scale 3/6, with porcelain scale	0	5	6

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	£	s.	d.
Pocket Thermometer, ivory scale, in Morocco case, 3-inch 5/6, 4-inch 6/6, 5-inch 8/, 7-inch 10/6, 8-inch	0	11	6
Ditto, ditto, for showing the greatest degree of cold	0	10	0
Ivory Thermometer, in German silver case, for waistcoat pocket	0	9	6
Ivory Pocket Thermometer, in revolving German silver case	0	10	0
Boxwood Pocket Thermometer, enclosed bulb ...	0	4	6

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FOR SHOWING THE AMOUNT OF MOISTURE IN THE ATMOSPHERE.

The indications of these instruments will assist an observer in foretelling the weather.

	£	s.	d.
Dew Point Thermometer, box scale	0	7	6
Ditto, ditto, zinc scale	0	15	0
Ditto, ditto, slate scale	0	14	0
Ditto, ditto, porcelain scale	0	14	0
Daniel's Hygrometer, in case	2	10	0

RAIN GAUGES.

	£	s.	d.
Rain Gauge, as used by the British Association, japanned 10/, copper	0	14	0
Glaisher's Rain Gauge, japanned	1	0	0
Ditto, ditto, in copper	1	15	0

BAROMETERS.

	£	s.	d.
Pediment Barometer, glass tube, mounted on mahogany divisions and letters on ivory scale, covered with plate glass	0	12	6
Ditto, ditto, larger tube, mounted on rosewood frame, ivory scale	1	5	0
Ditto, ditto, very bold, carved frame, in oak or walnut, scales of ivory, porcelain, or enamelled glass ... ... £3 10s., £5, £8, and	10	0	0
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Best ditto, with polished black circular frame, 9 or 11 inches diameter, for a hall or library	2	10	0
Best ditto, with Thermometer	2	15	0
Best ditto, with engraved metal dial	2	15	0
Best ditto, ditto, with Thermometer	3	0	0
Best ditto, ditto, with open dial showing works ...	3	10	0
With carved oak frame and enamelled dial, for a hall or library	3	5	0
Ditto, with Thermometer	3	10	0
Ditto, extra carved oak frame, engraved metal dial showing works	4	5	0
Ditto, ditto, with Thermometer from £4 10s. to	4	15	0
Ditto, oak frame, same form as Wheel Barometer, with Thermometer attached above dial from £5 5s. to	8	8	0
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	£	s.	d.
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Ditto, carved oak frame	20	0	0
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Best Watch form Aneroids, compensated for temperature and constructed expressly for measuring heights, with altitude scale, 1½, 1¾, or 2-inch diameter ... ... each	5	5	0
Best Pocket form Aneroid Barometer, 2½-inch, 3-inch, and 3½-inch diameter, compensated for temperature, with or without elevation scale on the dial ...	6	0	0
Aneroid Barometer, specially constructed for surveying purposes, as supplied to H.M. Indian Government, dial 4-inch or 5-inch in diameter, with or without elevation scale, in solid leather sling case	7	10	0

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"THE ANEROID AND HOW TO USE IT."—32 pages, with 12 Illustrations, and Tables of Altitude, Price 6d. Sent, post paid, for Seven Stamps.

ANEMOMETERS.

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Lind's Anemometer, with vane	1	5	0
Robinson's Anemometer	3	10	0
Ditto, as improved and made by Browning for the Royal Observatory, Greenwich	7	10	0

CHEMICAL THERMOMETERS.

	£	s.	d.
Chemical Thermometer, divided and engraved on stem, 0° to 300°	0	5	6
Ditto, ditto, very accurate,—30° to +400°, 7/6; 0° to 70C°	0	10	0

STANDARD METEOROLOGICAL INSTRUMENTS.

Any of these Instruments will be sent for verification to Greenwich or Kew Observatory, if desired.

	£	s.	d.
Standard Thermometer, metal scale, in Morocco case	2	2	0
Standard Maximum Thermometer, on Phillips's principle, the divisions etched on the glass tube, and the figures enamelled on porcelain scale	1	0	0
Standard Minimum Thermometer to match the above Maximum	1	0	0
Mason's Hygrometer, or dew-point thermometer; scales of metal, glass, or porcelain ... £2 to	2	10	0
Minimum Thermometer, on brass pedestal, to take dew-point on grass	0	16	0
Standard Solar Maximum, insulated	1	4	0
Standard Barometer, entirely of metal, with fiducial point in glass cistern, divided to be read by estimation to $\frac{1}{1000}$th of an inch	8	8	0
Standard Barometer, very large; internal diameter of tube, 0·75	20	0	0
Mountain Barometer, in metal, with tripod stand, in leather or sling case	8	10	0
Hypsometrical Apparatus for estimating height by the boiling-point of water ... ... £5 to	6	10	0

APRIL, 1876.

The following Prices are Nett for Cash; half-price allowed for returned Packages, if Carriage Paid.

JOHN BROWNING'S
PRICED LIST OF MICROSCOPES.

	£	s.	d.
1. Microscope, large size, with coarse and fine Mechanical Adjustments, Mechanical Stage with rectangular and circular motions, secondary stage with complete centring adjustments, graduated Drawer Tube, plane and concave Mirror, large size, with double jointed arm, large size Condenser, A, B, and C Eye-pieces. 2-inch, 1-inch, and ¼-inch Objectives, first quality, packed in highly finished upright Mahogany Case ...	36	10	0
2. The above-named Instrument, Binocular, with rack and pinion adjustment to Drawer Tubes ...	42	0	0
3. Microscope, smaller size, with all the above adjustments, A and B Eye-pieces, Condenser for opaque objects, 1-inch 25° and ¼-inch 85° with adjustment for correction to Objectives	16	10	0
4. The above Instrument, Binocular, with Rack motion to Drawer Tubes	21	0	0
4.*With Stephenson's Binocular arrangement ...	25	0	0
5. Microscope, same size, with coarse and fine Mechanical Adjustments, Mechanical Stage, &c., graduated Drawer Tube, large size plane and concave Mirrors with jointed arm, A Eye-piece, and 1-inch 16° and ¼-inch 85° Objectives, with correcting adjustment	12	0	0
6. The above Instrument, Binocular	15	10	0

	£	s.	d.
The "Complete" Microscope. This Instrument has a highly finished brass Stand, Rack, and fine adjustment to body, and Mechanical motions to stage, and is supplied with an Eye-piece, and two high-class Objectives, 1-inch and ¼-inch, of which the performance will be guaranteed ...	7	10	0
The above Instrument, Binocular	10	10	0
7. The Model Microscope, with Rack and fine adjustments to body, with Axis for Inclination, one Eye-piece, Concave Mirror, and 1-inch Objective, and ¼-inch object glasses	5	10	0
The New Pocket, or Field Microscope, on firm folding brass Tripod Stand, with fine adjustment, 1-inch Objective of good quality, large field Eye-piece, Hand Pliers, &c., packed in Morocco Case, 5½-inch long	1	11	6
The above-named Instrument, with 2-inch Objective, Stage Forceps, Stage Plate, and Dipping Tubes	2	2	0
The Youth's Microscope, in case, complete, 8/6, 12/6, 15/	1	1	0
Binocular arrangement fitted to any instrument, with adjustment to Eye-drawers, and one extra Eye-piece	3	15	0
Ditto, with pair of Eye-pieces	4	10	0
Ditto, with Rack adjustments...	5	10	0
Adapting Stephenson's Binocular arrangement to Student's stands, with two Eye-pieces, and sliding adjustment to draw tubes	7	0	0
To medium sized stands, with rack adjustment to the draw tubes	9	10	0
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Polarizing plane for this size, with fittings, extra ...	2	10	0

Microscope Object Glasses.

No. 1.

Power.	Angle.	Price.	Lieberkuhn.
3 in. ...	10 degrees ...	£2 0 0 ...	
2 in. ...	16 „ ...	2 0 0 ...	£0 15 0
1½ in. ...	20 „ ...	2 5 0 ...	0 15 0
1 in. ...	25 „ ...	2 10 0 ...	0 12 6
½ in. ...	60 „ ...	3 0 0 ...	
⅔ in. ...	35 „ ...	3 0 0 ...	0 10 6
*½ in. ...	85 „ ...	4 10 0 ...	
¼ in. ...	85 „ ...	3 0 0 ...	
*¼ in. ...	100 „ ...	4 10 0 ...	
*⅛ in. ...	135 „ ...	7 10 0 ...	

The powers marked thus (*) are furnished with screw collar adjustment.

Low Angle Lenses.

No. 2.

Power.	Angle.	Price.
2 in. ...	10 degrees. ...	£1 5 0
1 in. ...	15 „ ...	1 5 0
½ in. ...	55 „ ...	2 0 0
¼ in. ...	75 „ ...	2 2 0

Microscopic Apparatus.

		£	s.	d.
Extra Eye-pieces	12/6 and	0	15	0
Indicator for ditto, extra		0	5	0
Kellner's Achromatic Eye-piece ...	£1 and	1	5	0
Stage Micrometer		0	5	0
Ditto, mounted in brass frame		0	10	0
Eye-piece Micrometer		0	5	0
Ditto, with brass fittings and screw adjustments ...		1	0	0
Erecting Eye-piece		1	0	0

		£	s.	d.
Camera Lucida	15/ and	1	0	0
Beales's ditto		0	7	6
Achromatic Condenser, with revolving Diaphragm and full set of Stops		5	0	0
Achromatic Condenser...		2	10	0
Webster's ditto		2	0	0
Ditto, with Rack Adjustment and graduated Diaphragm		4	0	0
Wenham's Parabola, for dark ground illumination,	21/ to	1	11	6
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Stage Condensers		0	7	0
Stand ditto ...	No. 1, 2, 3, 4, 9/6, 12/6, 17/6	1	1	0
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Parabolic ditto		1	2	6
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Selenite Stage Plates		0	2	0
Rotating Object Holder		0	12	6
Lever Compressorium		0	18	6
Lister's Dark Wells	from 5/ to	0	12	6
Live Cages	from 4/6 to	0	7	6
Stage Forceps	from 4/6 to	0	7	6
Hand Forceps	2/6 and	0	4	6
Maltwood's Finder		0	7	6
Glass Troughs	from	0	1	6
Zoophyte ditto		0	6	0
Microscope Lamps	from 12/6 to	0	16	0
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		£	s.	d.
Machine for cutting sections of wood ...	from	0	15	6
Dissecting Knives	each	0	3	0
Valentine's ditto	...	1	1	0
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Fine ditto	...	0	3	0
Elbow ditto	...	0	4	6
Steel Forcep	...	0	3	0
Ditto, curved	...	0	3	0
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Brass Table and Spirit Lamp for mounting objects,	7/6 and	0	10	6
Rotating Table for making Cells	from	0	7	6
Air Pump for Mounting	...	1	0	0
Plate Glass Slides, 3-inch by 1-inch ...	per doz.	0	0	4
Ditto, ditto, with ground edges	,,	0	0	8
Ditto, ditto, ditto, and excavated Cells ...	,,	0	2	6
Ditto, ditto, ditto, round glass ditto	,,	0	3	6
Ditto, ditto, ditto, square ditto	,,	0	5	0
Thin covering glass, circles, various sizes ...	per oz.	0	5	0
Ditto, ditto, squares ditto	...	0	3	6
Adhesive Labels for covering objects	per 100.	0	1	6
Canada Balsam...	from per bottle	0	0	6
Asphaltum	...	0	0	6
Gold Size	...	0	0	6
Dean's Gelatine Medium	...	0	1	0
Glycerine, pure...	...	0	1	0
Marine Glue	6*d.* and	0	1	0
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The Sorby-Browning Micro-Spectroscope	5	15	0
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Ditto ditto	2 ditto	... ...	0	1	0
Ditto ditto	3 ditto	... ...	0	1	6
Polished Mahogany ditto	2 ditto	... ...	0	5	6
Ditto ditto	3 ditto	... ...	0	7	6
Ditto ditto	6 ditto	... ...	0	15	0
Upright Polished Pine Cabinet, with drawers to hold 120 objects		... ...	0	18	6
Ditto, ditto, ditto, to hold 250 ditto		.. ..	1	12	6
Ditto, ditto, ditto	500 ditto	... ...	2	10	0
Polished Upright Solid Mahogany Cabinet, with drawers to hold 120 objects		... ...	1	10	0
Ditto, ditto, ditto, to hold 250 objects		... ...	2	17	6
Ditto, ditto, ditto	500 ditto	.. ...	4	10	0
Ditto, ditto, ditto	750 ditto	... ...	6	0	0
Ditto, ditto, ditto	1,000 ditto	... ...	7	15	0
Best ditto, ditto	ditto	... ...	7	15	0

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TO LECTURERS ON SCIENCE.

JOHN BROWNING begs to announce that he has prepared, with peculiar care, the following Diagrams, to illustrate recent discoveries in Spectrum Analysis and other branches of Observational Astronomy.

	£	s.	d.
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,, ,, (coloured)	0	8	6
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,, ,, (coloured)	0	7	6
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,, ,, ,, ,, ,, (coloured)	0	4	6
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,, ,, ,, ,, (coloured)	0	4	6
,, ,, 1869 (Gillman)	0	3	6
,, ,, ,, ,, (coloured)	0	6	6
View of Total Eclipse of 1870, taken by Lord Lindsay, F.R.A.S. at Cadiz	0	4	6
,, ,, ,, ,, (coloured)	0	7	6
Two Views Prominences (Lockyer) .. each	0	3	6
,, ,, ,, (coloured)	0	4	6
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,, ,, ,, (coloured)	0	4	6
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,, (Secchi)	0	3	6
,, (Herschel)	0	3	6
,, (Browning)	0	3	6
,, (Howlett) 2 Views .. each	0	3	6
Ideal View of Solar Surface (Huggins)	0	3	6
View of Equatorial Telescope, as used in India..	0	3	6
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Total Eclipse of 1870, taken by the American Observers near Cadiz	0	4	6

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	£	s.	d.
Lines of Solar Spectra, with chemical coincidences	0	3	6
" " " " .. (coloured)	0	7	6
" " coincidences of iron lines	0	3	6
" " " "	0	7	6
Spectrum, Sirius "	0	3	6
" " (coloured)	0	7	6
" Corona "The World on Fire"	0	3	6
" " " " (coloured)	0	7	6
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" " " " (coloured) ..	0	8	6
" F in Line Hydrogen, "Sirius and Sun" (on 1 slide)	0	3	6
" " " " " (coloured)	0	7	6
" Comets, Nebula, &c. (on 1 slide)	0	3	6
" " " " (coloured)	0	7	6
" Aldebaran and *a* Orionés	0	3	6
" " " (coloured)	0	7	6
Part of Solar Spectra (Bunsen and Kirchoff)	0	3	6
" " " " (coloured) ..	0	7	6
F Line, as seen on the Sun (Lockyer)	0	3	6
" " near small spots	0	3	6
Lines of the Spectrum of any Gas or Metal (coloured).. each	0	5	0

These Diagrams will be sent out on hire, at a charge of 1s. each Diagram for three days, and 6d. extra for each additional three days.

Illustrated List of Electric Lamps and Lantern Apparatus on application.

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